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EFFECT OF RATE AND DURATION OF FEEDING DDT ON THE REPRODUCTION OF SALMONID FISHES REARED AND HELD UNDER CONTROLLED CONDITIONS [1]

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ABSTRACT

Losses of fry during various periods of development are compared for brown trout and brook trout hatched from eggs taken from females fed DDT at different concentrations and for various lengths of time, and for control fish held under identical conditions and fed the same ration except for DDT. Significant differences for the various periods of development were determined by the "*t*" test. Only one period, from swim-up (i.e., when hatchery feeding is normally begun) for a specified time thereafter, showed significant losses, depending on the time DDT was fed before spawning and the weekly dosage in milligrams per kilogram of body weight.

DDT was confirmed as the cause of approximately 100 per cent mortality of lake trout fry reared from eggs taken after adding 6 milligrams of DDT per kilogram of body weight to the weekly diet of potential breeders that had been reared from the egg at normal hatchery procedures until they neared maturity. A single control had no recorded loss of fry during this period.

Study of the effect of DDT on the reproduction of lake trout (Burdick et al., 1964) raised questions of whether similar effects might not occur with other salmonids. Small-scale studies were commenced at that time using brown trout and brook trout. Collection of wild fish under different conditions of DDT exposure and holding them until maturity proved unsatisfactory. Therefore, it was decided to feed DDT to hatchery breeding stock accustomed to the conditions in which they were held. Use of eggs from a single female per lot permitted taking into account the variability between lots in determining whether dif-

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ferences between means for the losses of eggs from treated and untreated females were significant. This approach would also give a true range of variation between individual lots, which could be hidden or eliminated if a mixed lot of eggs from the same treatment were used.

Allison et al. (1963, 1964) had exposed cutthroat trout to different concentrations of DDT and found (apparently with combined lots of eggs) that high mortality occurred near the end of the yolk sac stage. Macek (1968) reported significant losses among brook trout, based on accumulated totals in what are believed to have been mixed lots of eggs from parental stock exposed to DDT at various concentrations and mated to either exposed or unexposed stock of the opposite sex. Heaviest losses occurred near the end of the sac fry period. Many papers tend to combine all forms of the DDT complex, including DDE, though the latter is relatively non-toxic compared with o-p and p-p DDT and TDE. Laboratory studies, involving force-feeding brook trout a capsule of DDE in oil at up to 1,000 milligrams per kilogram of body weight, failed to cause mortality (unpublished data, N.Y.S. Department of Environmental Conservation).

No one has reported on similar reproductive studies using brown trout or brook trout on an individual fish basis. It is also desirable to confirm that, under controlled conditions, DDT can produce losses similar to those developing in wild fish from natural waters.

METHODS

The methods described applied to brown trout and brook trout. Generally, they also applied to lake trout except as otherwise stated in the text.

Breeding females were obtained from State fish hatcheries. They had been raised from the egg in the hatchery system and had matured and spawned once. The fish had been exposed only to substances naturally present in the hatchery water. Brown trout and brook trout were brought to the Rome hatchery and placed in a wooden raceway fed by springwater. The structure was compartmented, and the control fish were held above those fed DDT.

A calculated concentration of DDT in dry feed was made by mixing technical DDT dissolved in natural oil with dry feed in a ratio that would give the approximate concentration desired when mixed with ground meat in a 2/7 to 5/7 mixture. The dosage in milligrams of DDT per kilogram of fish weight was then calculated in terms of the weekly rate of feeding. Generally, fish were fed the mixture three times per week.

Eggs were taken by stripping, fertilized with milt from two untreated hatchery males and waterhardened, after which 500 eggs (if available) were taken for hatching. The number of fish used was gov-

erned both by the space available for holding or hatching and handling and by the number that matured eggs. In 1959, hatchery trays were separated by dividers into three longitudinal sections, and these trays were placed in a hatchery trough and wedged above the bottom. Trough dividers were used to obtain circulation.

In 1962, a battery hatching system was devised to permit handling a greater number of eggs per year. A 2-inch-diameter iron pipe was drilled and tapped for ¼-inch iron nipples to be screwed in and angled downward. These were placed every 2 inches, alternately on opposite sides of the pipe, for a total of 44. A short piece of tubing and a disconnect connector were attached to each nipple followed by a section of glass tubing with smaller bore glass tubing coupled to it. This permitted fast removal of the tube for cleaning or removal of the egg jar for picking. Flow in each tube was adjusted by means of a screw clamp. The manifold was fed springwater from a head trough at one end of the pipe in which a constant head was maintained. The apparatus was installed horizontally over the center space between two hatchery troughs which supported the eggs jars and formed a drain for used water.

For hatching jars, 500-milliliter polyethylene bottles were used. The caps were removed and screwed to a board so as to center under the nipples on each side. The bottom of each bottle was removed, a rubber stopper was fitted to the neck and then the bottle was screwed into the cap attached to the board. Holes were bored in the upper periphery of the inverted bottle to allow water to escape. Later, aluminum screening held by rubber bands was used to cover these holes and extend the exposed end to prevent loss of fry at swim-up. The neck was filled with small gravel to the top of the constriction, and a piece of aluminum screening with a hole in the center was added above the gravel. The small-bore tubing was inserted through this hole into the gravel to allow the water to diffuse evenly through the layer of eggs placed on the screen. Treatment, if needed, could be applied through the head trough.

Dead eggs and fry were removed almost daily, even though this might contribute to a somewhat higher loss during the egg stage. This was to minimize the development of fungus which could affect contiguous normal eggs. In the battery hatching, developing fungus caused error in counts due to difficulty in separating individual eggs. Rupture of eggs can also prevent an accurate count of egg mortality. Egg losses were not considered as caused by DDT. A daily record of counted mortality was maintained and formed the basis for determining egg losses as well as losses of fry from hatching to feeding and from feeding to a specified time thereafter.

A g-l chromatograph with electron capture detector permitted

analysis of individual lots for DDT in 1964. The procedure used was described by Burdick et al. (1968). Shortcomings of this procedure were corrected by packing with 2.5 per cent QF1 + 5 per cent DC 200 silicone on 80-90 mesh Gas-Chrom before the lake trout eggs were analyzed.

MATHEMATICAL AND STATISTICAL PROCEDURES

While it is generally believed that back-calculation from counted remainders and losses provides a more accurate measure of mortality among fry from hatching to a specified time after feeding, since an exact count of egg loss is difficult, this mortality was also computed based on the initial number of eggs minus the counted egg loss. Comparison of the two methods is illustrated in Tables 5 and 4, respectively, which indicate the losses among different lots of brown trout from hatching to feeding and from feeding to 40 days thereafter. The base used in these tables permits adding the percentages of loss for the two periods to give a cumulative loss for the entire time.

Mortality was also computed for each period on the basis of the calculated number of fry at the beginning of the period, i.e., hatching or feeding (see Table 6), as had been done for lake trout (Burdick et al., 1964).

The methods recommended by Snedecor (1956) were used to determine "*t*" values for the difference between means for control fish and DDT-fed fish in samples with unequal standard deviation and either equal or unequal numbers. Also, his four-fold contingency tables for independence were used to combine data for a given species based on the number of lots falling above or below a year's group mean for the fed and unfed lots. This allows increasing the size of the treated lots which may fail to show significance because of the small number of fish used.

RESULTS

The data gathered during this study are summarized in the various tables and are discussed separately with respect to the species involved.

BROWN TROUT

Brown trout studies were started in 1959 when the female fish were fed 0.15 milligram of DDT per kilogram of body weight per week. In 1960 the corresponding rate was 0.49 milligram. The data with respect to the survival of eggs and resultant fry from these fish, as well as control fish, are given in Tables 1 and 2. No significant effect of DDT on survival was found for any period, due in part to the low level at which it was fed. Also, the small number of lots would make determination of significance difficult unless the means were widely divergent.

TABLE 1. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROWN TROUT EGGS AND RESULTANT FRY IN 1959-60 BASED ON COUNTED EGG LOSSES

	Eggs		Fry					
				Losses to 33 days after feeding				
				Hatching to feeding		Feeding to 33 days		Total
Lot	Taken	Counted loss	Hatched	Number	Per cent	Number	Per cent	(per cent)
5C	500	25	475	6	1.3	7	1.5	2.8
11C	500	89	411	16	3.9	17	4.1	8.0
18C	500	50	450	32	7.1	42	9.3	16.4
Average								9.1
7E	500	65	435	50	11.5	17	3.9	15.4
8E	500	76	424	15	3.5	34	8.0	11.5
10E	500	29	471	61	12.9	90	19.1	32.0
13E	500	160	340	97	28.5	80	23.5	52.0
14E	500	26	474	38	8.0	41	8.6	16.6
16E	500	221	279	85	30.5	36	12.9	43.4
17E	500	8	492	7	1.4	60	12.2	13.6
Average								26.4

TABLE 2. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROWN TROUT EGGS AND RESULTANT FRY IN 1960-61 BASED ON COUNTED EGG LOSSES *

	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
Lot §	Taken	Counted loss	Hatched	Number	Per cent	Number	Per cent	(per cent)
2C	500	11	489	3	0.6	1	0.2	0.8
5C	500	310	190	20	10.5	3	1.6	12.1
Average								6.5
4E	500	37	463	3	0.6	3	0.6	1.2
12E	500	44	456	25	5.5	20	4.3	9.8
13E	500	12	488	4	0.8	5	1.0	1.8
14E	500	481	19	6	31.6	1	5.3	36.9
Average								12.4

* These eggs were all from second-year spawners that had been under light control in their first year to induce early spawning.
§ Control lot 9C eliminated because of gill disease.

In 1961, the females were fed DDT at an average rate of 1.01 milligrams per kilogram of body weight per week for 14 weeks, although the rate was 1.14 milligrams for the last 10 weeks. Losses are shown in Table 3. Again, no significant effect of DDT was found for any period (Table 6).

In 1962, the females were fed 3.39 milligrams of DDT per kilogram of body weight per week for 44 weeks. Survival data for the fry are given in Tables 4 and 5. Analysis (Table 6) showed a significant difference for the means of both the losses from hatching to 40 days after feeding and the losses from feeding to 40 days after feeding and

TABLE 3. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROWN TROUT EGGS AND RESULTANT FRY IN 1961-62 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days *		Total (per cent)
	Taken	Counted loss	Hatched	Number	Per cent	Number	Per cent	
4C	500	117	383	13	3.4	24	6.3	9.7
11C	500	46	454	12	2.6	31	6.8	9.4
17C	500	22	478	1	0.2	97	20.3	20.5
28C	500	36	464	23	5.0	292	62.9	67.9
30C	500	74	426	11	2.6	183	43.0	45.6
32C	500	76	424	41	9.7	260	61.3	71.0
33C	500	427	73	19	26.0	44	60.3	86.3
35C	500	102	398	41	10.3	156	39.2	49.5
37C	500	86	414	20	4.8	197	47.6	52.4
Average								45.8
5E	500	113	387	16	4.1	4	1.0	5.1
12E	500	143	357	31	8.7	32	9.0	17.7
16E	500	79	421	36	8.6	78	18.5	27.1
18E	500	92	408	19	4.7	195	47.8	52.5
27E	500	47	453	13	2.9	162	35.8	38.7
29E	500	88	412	24	5.8	370	89.8	95.6
31E	500	239	261	13	5.0	152	58.2	63.2
36E	500	405	95	6	6.3	62	65.3	71.6
38E	500	149	351	93	26.5	226	64.4	90.9
Average								51.4

* Some lots were combined after 25 days of feeding.

the losses from feeding to 40 days thereafter. The difference was significant whether the figures used for the number of fry hatched were based on the counted egg losses or on back-calculation. No significance was found for the period from hatching to feeding even when the data were combined and treated according to Snedecor's four-fold contingency tables. The significance of the effect for both periods combined was due to the fact that the losses after feeding outweighed the variability that occurred prior to that time. It is apparent that the effect was largely restricted to the period following feeding when the triglyceride fats are utilized, as had been found for lake trout. It seems that only this period is important. It is concluded that DDT fed at levels in this range can adversely affect brown trout reproduction. The syndrome during this time was similar to that shown in the previous study for lake trout.

BROOK TROUT

Studies of brook trout reproduction were begun with the collection of eggs from DDT-fed females in 1962. Similar collections of eggs were made in 1963, 1964 and 1965. The rate and duration of feeding DDT each year are shown in Table 15. Use of the hatchery battery permitted more eggs to be handled and simplified the problem of

TABLE 4. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROWN TROUT EGGS AND RESULTANT FRY IN 1962-63 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
	Taken	Counted loss	Hatched	Number	Per cent	Number	Per cent	(per cent)
20C	494	35	459	8	1.8	4	0.9	2.7
25C	500	40	460	3	0.7	44	9.6	10.3
27C	500	46	454	10	2.2	28	6.2	8.4
29C	500	65	435	16	3.7	13	3.0	6.7
31C	500	32	468	26	5.3	49	10.5	15.8
35C	500	326	174	24	13.8	7	4.0	17.8
37C	500	53	447	8	1.8	4	0.9	2.7
39C	500	53	447	12	2.7	13	2.9	5.6
41C	500	33	467	4	0.9	21	4.5	5.4
43C	500	32	468	6	1.3	16	3.4	4.7
Average								8.0
18E	500	138	362	2	0.5	42	11.6	12.1
24E	500	114	386	8	2.1	120	31.1	33.2
30E	500	87	413	17	4.1	191	46.2	50.3
32E	500	141	359	17	4.7	78	21.7	26.4
34E	500	32	468	38	8.1	142	30.3	38.4
36E	336	318	18	2	11.1	1	5.6	16.7
38E	500	64	436	30	6.9	57	13.1	20.0
40E	500	169	331	7	2.1	321	97.0	99.1
Average								37.0

TABLE 5. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROWN TROUT FRY IN 1962-63 BASED ON BACK-CALCULATION OF FRY HATCHED

Lot	Calculated fry	Number remaining at end	Losses 40 days to end	Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
				Number	Per cent	Number	Per cent	(per cent)
20C	337	0	325	8	2.4	4	1.2	3.6
25C	136	53	36	3	2.2	44	32.4	34.6
27C	240	137	65	10	4.2	28	11.7	15.9
29C	329	65	235	16	4.9	13	4.0	8.9
31C	303	78	150	26	8.6	49	16.2	24.8
35C	86	55	0	24	27.9	7	8.1	36.0
37C	297	163	122	8	2.7	4	1.3	4.0
39C	206	99	82	12	5.8	13	6.3	12.1
41C	338	229	84	4	1.2	21	6.2	7.4
43C	277	221	34	6	2.2	16	5.8	8.0
Average								15.5
18E	285	2	237	2	0.7	42	14.7	15.4
24E	283	93	62	8	2.8	120	42.4	45.2
30E	252	15	29	17	6.7	191	75.8	82.5
32E	316	10	211	17	5.4	78	24.7	30.1
34E	429	2	247	38	8.9	142	33.1	42.0
36E	44	15	26	2	4.5	1	2.3	6.8
38E	107	6	14	30	28.0	57	53.2	81.2
40E	330	2	0	7	2.1	321	97.2	99.3
Average								50.3

TABLE 6. SUMMARY OF DATA ON FEEDING DDT TO FEMALE BROWN TROUT AND EFFECT ON THE EGGS AND FRY OF THESE FISH FOR DIFFERENT PERIODS OF DEVELOPMENT

Item	1961-62 (Based on counted egg loss—Table 3)		1962-63 (Based on counted egg loss—Table 4)		1962-63 (Based on calculated fry—Table 5)	
	Control	Experiment	Control	Experiment	Control	Experiment
DDT feeding						
Amount fed *	xxx	1.14§	xxx	3.39	xxx	3.39
Weeks fed	xxx	14	xxx	44	xxx	44
Number of egg lots	9	9	10	8	10	8
Effect on fry for period from hatching to feeding						
Loss (per cent) †						
Mean	7.2	8.1	3.4	5.0	6.2	7.4
Range	0.2-26.0	2.9-26.5	0.7-13.8	0.5-11.1	1.2-27.9	0.7-28.0
"*t*" value °	0.254 (ns)		0.869 (ns)		0.305 (ns)	
Effect on fry for period after feeding						
Days after feeding	25	25	40	40	40	40
Loss (per cent) ‡						
Mean	43.0	48.0	4.8	33.4	10.0	47.2
Range	6.7-81.5	1.1-95.4	0.9-11.1	6.3-99.1	1.2-33.1	2.4-99.4
"*t*" value °	0.345 (ns)		2.698 (< .05)		2.976 (< 0.25)	
Effect on fry for both periods combined						
Loss (per cent) †						
Mean	45.8	51.	8.0	37.0	15.5	50.3
Range	9.4-86.3	5.1-95.6	2.6-17.8	12.1-99.1	3.6-36.0	6.8-99.3
"*t*" value °	0.399 (ns)		2.665 (<.05)		2.773 (< .05)	

* In milligrams per kilogram of body weight per week.
§ Amount fed during last 10 weeks; 14-week average was 1.01 milligrams.
† Based on calculated fry hatched.
‡ Based on calculated fry to start of feeding.
° For difference of means; probability shown in parentheses, "ns" means not significant.

spread of any disease that might appear in any lot of fry. But it also produced complications in connection with picking eggs because either an additional layer of eggs might hide those beneath or hatched sac fry might lie above unhatched eggs. Occasionally, mats of unhatched, fungused eggs were removed for which counts were not exact.

Survival data for the different years, based on estimates of hatched fry derived from counted egg losses and by back-calculation, are given in Tables 7 to 14. Further analyses of the effect of each procedure are presented in Tables 15 and 16.[2] The time period, i.e., hatching to 40 days after feeding, was the same as that adopted for monitoring work on affected lake trout waters following the previous study of lake trout and placed the data on a comparable basis.

While nearly 100 percent mortality occurred in some lots, it was not the rule as it was with lake trout. The smaller number of eggs

[2] In Tables 9 to 14 and Table 17, the 10 fry noted as removed from various lots at certain times constituted the samples used for analysis.

TABLE 7. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT EGGS AND RESULTANT FRY IN 1962-63 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
	Taken	Counted loss	Hatched	Number	Per cent	Number	Per cent	(per cent)
1101C	500	18	482	11	2.3	21	4.4	6.7
1102C	500	120	380	2	0.5	32	8.4	8.9
1104C	500	58	442	13	2.9	59	13.3	16.2
1105C	500	388	112	3	2.7	50	44.6	47.3
1117C	500	99	401	4	1.0	119	29.7	30.7
1118C	500	64	436	21	4.8	133	30.5	35.3
1119C	500	37	463	5	1.1	75	16.2	17.3
1120C	500	21	479	6	1.3	254	53.0	54.3
1122C	500	64	436	7	1.6	84	19.3	20.9
1124C	500	74	426	19	4.5	53	12.4	16.9
Average								25.5
1121E	500	114	386	19	4.9	305	79.0	83.9
1136E	500	45	455	24	5.3	401	88.1	93.4
1138E	500	93	407	22	5.4	306	75.2	80.6
1140E	500	59	441	4	0.9	416	94.3	95.2
Average								88.3

TABLE 8. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT FRY IN 1962-63 BASED ON BACK-CALCULATION OF FRY HATCHED

Lot	Calculated fry	Number remaining at end	Losses 40 days to end	Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
				Number	Per cent	Number	Per cent	(per cent)
1101C	96	58	6	11	11.4	21	21.8	33.2
1102C	168	75	59	2	1.2	32	19.0	20.2
1104C	231	6	153	13	5.6	59	25.5	31.1
1105C	112	41	18	3	2.7	50	44.6	47.3
1117C	297	93	81	4	1.3	119	40.1	41.4
1118C	319	85	80	21	6.6	133	41.7	48.3
1119C	208	88	40	5	2.4	75	36.1	38.5
1120C	437	108	69	6	1.4	254	58.1	59.5
1122C	359	123	145	7	1.9	84	37.5	39.4
1124C	224	47	105	19	8.5	53	23.7	32.2
Average								39.1
1121E	324	0	0	19	5.9	305	94.1	100.0
1136E	425	0	0	24	5.6	401	94.4	100.0
1138E	328	0	0	22	6.7	306	93.3	100.0
1140E	421	0	1	4	1.0	416	98.8	99.8
Average								99.95

TABLE 9. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT EGGS AND RESULTANT FRY IN 1963-64 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
	Taken	Counted loss	Hatched*	Number	Per cent	Number	Per cent §	(per cent)
1038C	500	65	425	30	7.1	41	9.9	17.0
1039C	500	125	365	15	4.1	43	12.1	16.2
1043C	500	18	472	11	2.3	47	10.2	12.5
1051C	500	43	447	24	5.4	76	17.4	22.8
1052C	500	343	147	18	12.2	66	48.2	60.4
Average								25.8
1037E	500	76	414	14	3.4	322	79.7	83.1
1041E	500	191	399	9	2.3	36	9.3	11.6
1046E	500	263	227	19	8.4	106	48.8	57.2
1047E	500	117	373	38	10.2	14	3.9	14.1
1048E	500	40	450	15	3.3	167	38.0	41.3
1049E	500	40	450	27	6.0	371	84.3	90.3
1050E	500	18	472	14	3.0	386	83.5	86.5
Average								54.9

* 10 sac fry removed.
§ Based on corrected number of fry (i.e., 10 additional removed).

TABLE 10. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT FRY IN 1963-64 BASED ON BACK-CALCULATION OF FRY HATCHED

Lot	Calculated fry	Number remaining at end *	Losses 40 days to end	Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
				Number	Per cent	Number	Per cent §	(per cent)
1038C	428	300	47	30	7.0	41	9.8	16.8
1039C	281	206	7	15	5.3	43	15.9	21.2
1043C	211	135	8	11	5.2	47	23.4	28.6
1051C	447	333	4	24	5.4	76	17.5	22.9
1052C	135	38	3	18	13.3	66	52.8	66.1
Average								31.1
1037E	411	53	22	4	1.0	322	80.3	81.3
1041E	302	240	7	9	3.0	36	12.3	15.3
1046E	241	95	11	19	7.9	106	45.9	53.8
1047E	206	138	6	38	18.4	14	7.1	25.5
1048E	322	116	14	15	4.7	167	53.5	58.2
1049E	442	19	15	27	6.1	371	85.9	92.0
1050E	458	43	5	14	3.1	386	86.2	89.3
Average								59.3

* Reflects corrected number of fry during second period (see following footnote).
§ Based on corrected number of fry (i.e., 10 removed).

TABLE 11. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT EGGS AND RESULTANT FRY IN 1964-65 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
	Taken	Counted loss	Hatched*	Number	Per cent	Number	Per cent §	(per cent)
1059C	500	40	450	7	1.6	155	35.2	36.8
1060C	500	83	407	8	2.0	113	28.5	30.5
1061C	500	333	157	8	5.1	11	7.5	12.6
1064C	500	21	469	7	1.5	134	29.2	30.7
1065C	500	153	337	10	3.0	36	11.0	14.0
1066C	500	42	448	10	2.2	119	27.2	29.4
1067C	500	45	445	5	1.1	19	4.4	5.5
1068C	500	168	322	7	2.2	39	12.5	14.7
1069C	500	85	405	16	4.0	15	3.8	7.8
1070C	500	29	461	12	2.6	12	2.7	5.3
1071C	500	50	440	14	3.2	101	23.5	26.7
1072C	500	41	449	4	0.9	149	33.9	34.8
1091C	500	40	450	27	6.0	29	6.6	12.6
1096C	500	250	240	3	1.3	9	3.9	5.2
1097C	500	127	363	12	3.3	173	49.0	52.3
1098C	500	56	434	9	2.1	80	18.9	21.0
1104C	500	3	487	16	3.3	187	39.2	42.5
1114C	500	22	468	45	9.6	89	19.4	29.0
Average								22.8
1058E	500	63	427	15	3.5	125	30.0	33.5
1062E	500	53	437	15	3.4	142	33.3	36.7
1063E	500	197	293	4	1.4	64	22.6	24.0
1088E	500	107	383	3	0.8	136	36.5	37.3
1089E	500	5	485	23	4.7	227	47.8	52.5
1090E	500	10	480	3	0.6	143	30.4	31.0
1092E	500	47	443	39	8.8	133	30.7	39.5
1093E	500	78	412	155	37.6	63	15.7	53.3
1094E	500	64	426	15	3.5	238	57.2	60.7
1095E	500	153	337	20	5.9	105	32.1	38.0
1099E	500	22	468	22	4.7	133	29.0	33.7
1100E	500	150	340	17	5.0	247	74.8	79.8
Average								43.3

* 10 sac fry removed.
§ Based on corrected number of fry (i.e., 10 additional removed).

did not permit determination of DDT and its metabolites until a g-l chromatograph with an electron capture detector was obtained in 1964. The range of DDT concentrations in the eggs and the average concentrations are shown in Tables 15 and 16. Direct comparison with the previously published lake trout data (Burdick et al., 1964) cannot be made, since the latter were analysed by the Schechter-Haller procedure. It would appear that brook trout are somewhat less sensitive to DDT than are lake trout.

It should be noted again that in no case did the difference of the means for DDT-fed and unfed fish reach a level of significance for the period from hatching to feeding, even when the data for the four years

Table 12. Survival of Control and Experimental Lots of Brook Trout Fry in 1964-65 Based on Back-calculation of Fry Hatched

Lot	Calculated fry	Number remaining at end *	Losses 40 days to end	Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
				Number	Per cent	Number	Per cent §	(per cent)
1059C	377	191	14	7	1.9	155	42.2	44.1
1060C	406	239	36	8	2.0	113	28.5	30.5
1061C	127	93	5	8	6.3	11	9.4	15.7
1064C	396	239	6	7	1.8	134	34.7	36.5
1065C	210	143	11	10	4.8	36	18.0	22.8
1066C	402	236	27	10	2.5	119	30.4	32.9
1067C	140	85	21	5	3.6	19	14.6	18.2
1068C	172	108	8	7	4.1	39	24.1	28.2
1069C	175	126	8	16	9.1	15	9.1	18.2
1070C	206	151	21	12	5.8	12	6.1	11.9
1071C	344	205	14	14	4.1	101	30.2	34.3
1072C	357	190	4	4	1.1	149	42.9	44.0
1091C	148	70	12	27	18.2	29	21.0	39.2
1096C	42	19	1	3	7.1	9	28.1	35.2
1097C	335	123	17	12	3.6	173	53.2	56.8
1098C	287	121	67	9	3.1	80	28.8	31.9
1104C	366	118	35	16	4.4	187	52.5	56.9
1114C	372	185	43	45	12.1	89	24.6	36.7
Average								33.0
1058E	342	180	12	15	4.4	125	37.7	42.1
1062E	409	207	35	15	3.7	142	35.6	39.3
1063E	238	156	4	4	1.7	64	28.1	29.8
1088E	384	197	38	3	0.8	136	36.4	37.2
1089E	422	146	16	23	5.5	227	55.1	60.6
1090E	394	209	29	3	0.8	143	37.2	38.0
1092E	327	112	33	39	11.9	133	42.0	53.9
1093E	389	139	22	155	39.8	63	16.6	56.4
1094E	383	107	13	15	3.9	238	63.8	67.7
1095E	169	32	2	20	11.8	105	66.0	77.8
1099E	274	93	16	22	8.0	133	50.4	58.4
1100E	320	40	6	17	5.3	247	79.7	85.0
Average								53.9

* Reflects corrected number of fry during second period (see following footnote).
§ Based on corrected number of fry (i.e., 10 removed).

were combined and treated according to Snedecor's four-fold contingency tables. This was the case whether the figures for the number of fry at hatching were derived from counted egg losses or by back-calculation, although the two methods gave different degrees of probability. Feeding for a period of only 14 weeks, as in 1963, appeared to be too short to introduce sufficient DDT to cause a significant difference between the means for DDT-fed fish and unfed fish. The typical syndrome as described for lake trout occurred among fry in lots, from DDT-fed females, that showed substantial losses.

Lake Trout

On April 20, 1965, six female lake trout were obtained from the

TABLE 13. SURVIVAL OF CONTROL AND EXPERIMENTAL LOTS OF BROOK TROUT EGGS AND FRY IN 1965-66 BASED ON COUNTED EGG LOSSES

Lot	Eggs		Fry					
				Losses to 40 days after feeding				
				Hatching to feeding		Feeding to 40 days		Total
	Taken	Counted loss	Hatched*	Number	Per cent	Number	Per cent §	(per cent)
1463C	500	250	240	49	20.4	95	41.3	61.7
1464C	500	273	217	5	2.3	29	14.0	16.3
1465C	500	365	125	12	9.6	40	34.8	44.4
1466C	500	371	119	9	7.6	17	15.6	23.2
1467C	500	89	401	10	2.5	58	14.8	17.3
1472C	500	19	471	11	2.3	32	6.9	9.2
1473C	414	46	358	112	31.3	33	9.5	40.8
1474C	500	119	371	33	8.9	58	16.1	25.0
1475C	500	360	130	1	0.8	11	9.2	10.0
1476C	452	37	405	16	4.0	47	11.9	15.9
Average								26.4
1468E	500	48	442	18	4.1	392	90.7	94.8
1470E	500	65	425	20	4.7	324	78.1	82.8
1471E	500	52	438	32	7.3	377	88.1	95.4
1477E	500	395	95	12	12.6	38	44.7	57.3
1481E	500	75	415	4	1.0	225	55.6	56.6
1482E	401	34	456	4	0.9	320	71.7	72.6
1483E	500	36	454	20	4.4	362	81.5	85.9
1484E	500	185	305	21	6.9	107	36.3	43.2
1486E	500	275	215	1	0.5	69	33.7	34.2
1487E	500	238	252	5	2.0	162	66.9	68.9
Average								69.3

* 10 sac fry removed.
§ Based on corrected number of fry (i.e., 10 additional removed).

State fish hatchery at Fortsville, and six from the private hatchery of William Youngs near Glens Falls. In each case, they had been raised from the egg at the hatchery and were assumed to be nearly mature. These fish were transferred to the Warrensburg Experimental Hatchery, and feeding of DDT was started at a rate of 2 milligrams per kilogram of body weight per feeding which, at three feedings per week, corresponded to a weekly dosage of 6 milligrams per kilogram. None of these fish matured in 1965. Feeding at the same rate was continued through 1967. No females matured eggs, although at the source hatcheries litter-mates of one of the lots spawned successfully in the falls of 1965, 1966 and 1967. Mortality occurred at near spawning time, and at the end of 1967 only two of the original females remained. No symptoms of acute DDT poisoning appeared in any of the fish that died.

In February 1968, seven more females of the breeding stock at the Fortsville hatchery, together with the two remaining females at Warrensburg, were brought to the Rome hatchery where they were placed in a wooden raceway. Two of the females from Fortsville were sepa-

Table 14. Survival of Control and Experimental Lots of Brook Trout Fry in 1965-66 Based on Back-calculation of Fry Hatched

Lot	Calculated fry	Number remaining at end *	Losses to 40 days after feeding				Total (per cent)
			Hatching to feeding		Feeding to 40 days		
			Number	Per cent	Number	Per cent §	
1463C	233	79	49	21.0	95	42.2	63.2
1464C	225	176	5	2.2	29	13.5	15.7
1465C	135	73	12	8.9	40	32.0	40.9
1466C	120	84	9	7.5	17	15.5	23.0
1467C	383	305	10	2.6	58	15.5	18.1
1472C	204	151	11	5.3	32	16.5	21.8
1473C	356	201	112	31.5	33	9.5	41.0
1474C	327	226	33	10.1	58	18.3	28.4
1475C	121	99	1	0.8	11	9.9	10.7
1476C	387	314	16	4.1	47	12.5	16.6
Average							27.9
1468E	432	12	18	4.2	392	92.9	97.1
1470E	434	80	20	4.7	324	76.4	81.1
1471E	426	7	32	7.5	377	90.6	98.1
1477E	98	38	12	12.2	38	43.2	55.4
1481E	380	141	4	1.1	225	60.8	61.9
1482E	350	16	4	1.1	320	94.1	95.2
1483E	432	40	20	4.6	362	85.8	90.4
1484E	280	142	21	7.5	107	39.6	47.1
1486E	183	103	1	0.5	69	39.9	40.4
1487E	207	30	5	2.4	162	82.2	84.6
Average							75.1

* Reflects corrected number of fry during second period (see following footnote); experiment terminated at 40 days.
§ Based on corrected number of fry (i.e., 10 removed).

rated as controls. Feeding of DDT was continued at the same rate. No fish matured in 1968, which was assumed to have been due to the change in conditions and probably greater stress caused by public access to the location of the raceway.

In June 1969, the fish were transferred to a concrete pond to provide additional depth and space. The pond was partially covered and was not accessible to the public. A control fish was lost when it jumped from the water onto one of the covers. Feeding was continued at the same rate. On September 15, all the fish were transferred back to the wooden raceway. The remaining control fish ripened in November, and the eggs were stripped and fertilized with milt from a male from Fortsville on November 13. No development occurred in any of these eggs. On December 21, three of the experimental females were ripe. Since no ripe male lake trout was available, their eggs were fertilized with milt from male brook trout (producing splake). The eggs in one lot were too few for both hatching and analysis, and it was decided to use these eggs for analysis only. The fertilized eggs were eyed at Rome and transferred to Warrensburg. Approximately 100 per cent mortality had occurred in the fry by the 33rd day after feeding started. The

TABLE 15. SUMMARY OF DATA ON FEEDING DDT TO FEMALE BROOK TROUT AND EFFECT ON THE EGGS AND FRY OF THESE FISH AND CONTROL FISH FOR DIFFERENT PERIODS OF DEVELOPMENT BASED ON COUNTED EGG LOSSES (TABLES 7, 9, 11 and 13)

Item	1962-63		1963-64		1964-65		1065-66	
	Control	Experiment	Control	Experiment	Control	Experiment	Control	Experiment
DDT feeding								
Amount fed *	xxx	3.39	xxx	3.39	xxx	§	xxx	3.56
Weeks fed	xxx	44	xxx	14	xxx	35§	xxx	37
Number of egg lots	10	4	5	7	18	12	10	10
DDT in egg								
Average †	..	..	..	..	..	7.61	0.21	11.92
Range (o-p and p-p) ††	..		..	..	..	4.39-12.08	0.10-0.31	5.72-15.14
Effect on fry for period from hatching to feeding								
Loss (per cent) ‡								
Mean	2.3	4.1	6.2	5.2	3.1	6.7	9.0	4.4
Range	0.5-4.8	0.9-5.4	2.3-12.2	2.3-10.2	0.9-9.6	0.6-37.6	0.8-31.3	0.5-12.6
"*t*" value °	0.690 (ns)		0.490 (ns)		1.224 (ns)		1.394 (ns)	
Effect on fry for period after feeding								
Days after feeding ‡‡	40	40	40	40	40	40	40	40
Loss (per cent)								
Mean	23.7	87.9	21.5	52.6	20.4	39.0	19.8	67.5
Range	4.5-53.7	79.5-96.3	10.4-55.5	4.3-89.8	2.7-50.7	22.9-78.9	7.1-52.5	33.8-95.2
"*t*" value °	9.81 (<.001)		1.956 (ns)		3.234 (<.01)		5.724 (<.001)	
Effect on fry for both periods combined								
Loss (per cent) ‡								
Mean	25.5	88.3	25.8	54.9	22.8	43.3	26.4	69.3
Range	6.7-54.3	80.6-95.2	12.5-60.4	11.6-90.3	5.2-52.3	24.0-79.8	9.2-61.7	34.2-94.8
"*t*" value °	8.54 (<.001)		1.890 (ns)		3.678 (<.01)		4.976 (<.001)	

* In milligrams per kilogram of body weight per week.
§ Feeding suspended for 6 weeks (February 3-March 17); 7.07 milligrams fed for 9 weeks before, and 1.9 milligrams for 26 weeks after.
† Milligrams per kilogram calculated to concentration in fry at feeding.
†† DDE excluded.
‡ Based on calculated fry hatched.
‡‡ Based on calculated fry at start of feeding.
° For difference of means; probability shown in parentheses, "ns" means not significant.

TABLE 16. SUMMARY OF DATA ON FEEDING DDT TO FEMALE BROOK TROUT AND EFFECT ON THE EGGS AND FRY OF THESE FISH AND CONTROL FISH FOR DIFFERENT PERIODS OF DEVELOPMENT BASED ON BACK-CALCULATION OF HATCHED FRY (TABLES 8, 10, 12 and 14)

Item	1962-63		1963-64		1964-65		1965-66	
	Control	Experiment	Control	Experiment	Control	Experiment	Control	Experiment
DDT feeding								
Amount fed *	xxx	3.39	xxx	3.39	xxx	§	xxx	3.56
Weeks fed	xxx	44	xxx	14	xxx	35§	xxx	37
Number of eggs lots	10	4	5	7	18	12	10	10
DDT in egg								
Average †	..	..	..	..	..	7.61	0.21	11.92
Range (o-p and p-p) ††	..	..	..	.	..	4.39-12.08	0.10-0.31	5.72-15.14
Effect on fry for period from hatching to feeding								
Loss (per cent) ‡								
Mean	4.3	4.8	7.2	6.3	5.3	8.1	9.4	4.6
Range	1.3-11.4	1.0-6.7	5.2-13.3	1.0-18.4	1.1-18.2	0.8-39.8	0.8-31.5	0.05-12.2
"*t*" value	0.292 (ns)		0.335 (ns)		0.873 (ns)		1.464 (ns)	
Effect on fry for period after feeding								
Days after feeding ‡‡	40	40	40	40	40	40	40	40
Loss (per cent)								
Mean	34.8	99.95	26.4	55.6	29.2	49.6	21.2	74.0
Range	19.3-58.9	99.8-100	10.6-61.7	8.9-91.6	10.1-55.3	28.1-84.3	10.0-54.6	40.1-98.2
"*t*" value	16.329 (<.001)		1.848 (ns)		3.260 (<.01)		6.177 (<.001)	
Effect on fry for both periods combined								
Loss (per cent) ‡								
Mean	39.1	99.95	31.1	59.3	33.0	53.9	27.9	75.1
Range	20.2-59.5	99.8-100	16.8-66.1	15.3-92.0	11.9-56.9	29.8-85.0	10.7-63.2	40.4-98.1
"*t*" value	17.587 (<.001)		1.935 (ns)		3.235 (<.01)		5.489 (<.001)	

* In milligrams per kilogram of body weight per week.
§ Feeding suspended for 6 weeks (February 3-March 17); 7.07 milligrams fed for 9 weeks before, and 1.9 milligrams for 26 weeks after.
† Milligrams per kilogram calculated to concentration in fry at feeding.
†† DDE excluded.
‡ Based on calculated fry hatched.
‡‡ Based on calculated fry at start of feeding.
° For difference of means: probability shown in parentheses, "ns" means not significant.

Table 17. Survival of Control and Experimental Lots of Splake Eggs and Resultant Fry

Year and lot	Eggs taken	Fry							DDT at complete absorbtion of yolk ‡		
		Hatched	Losses to 33 days after feeding *				Total (per cent)	Number remaining at end	o-p	p-p	Total
			Hatching to feeding		Feeding to 33 days						
			Number	Per cent	Number	Per cent					
1970 (1C)	500	368 §	45	12.9	§	0.0	12.9	283	.	.	. .
1969 (1E)	500	237 †	92	40.5	133†	58.6	99.1	2	3.09	5.27	8.36
(3E)	1,000	341 †	237	71.6	92†	27.8	99.4	2	4.85	6.44	11.29

* Percentages corrected for fry removed for analyses.
§ 20 removed.
† 10 removed.
‡ In milligrams per kilogram based on analysis of egg and assuming no loss; DDE excluded.

data are presented in Table 17 in which the number of fry hatched was derived by back-calculation. The amount of DDT in the eggs used for analysis only, based on the average conversion of the other egg lots, was: o-pDDT 2.12, and p-pDDT, 3.70 or a total of 5.82 milligrams per kilogram.

In 1970, three experimental fish and one control remained. Feeding was continued at the same rate. The control fish matured eggs which were fertilized with brook trout milt and transferred to Fortsville where previous lake trout rearing had been conducted. The losses are listed in Table 17. No loss was recorded for the usual period after feeding. By June 14, 1971, the remaining fry totaled 283. Only a trace (less than 0.05 of p-pDDT was detectable in these eggs.

DISCUSSION

Due to the possibility of confusing the results, the usual routine therapeutic treatments used in the hatcheries were not used, except as pathological examination of dead or nearly dead fry showed evidence of disease. With the battery, this could be restricted to the lot or lots in which it was found. Due to the possibility of random loss of eggs from causes other than DDT (i.e., mucus or slime from stripping, blood in the eggs and possible variation in the ability of the sperm to fertilize the egg, as well as continual removal of dead eggs to avoid need for chemical treatment to prevent fungus which might have injured eggs nearby), this stage was not included in the computations or tested for significant difference of means. In no case was there a significant difference of means between lots for the hatching to feeding period. The major loss which could be attributed to DDT occurred during the period after feeding. The loss during this period was frequently so high that the means would still test as significantly different when the data for all three periods were combined.

Allison et al. (1963, 1964), in a study of cutthroat trout, noted an increase in mortality in spring and early summer. This species is an earily spring spawner (February-April). In the present study, the fall-spawning brown trout and brook trout showed similar losses following the spawning period when the fish had been handled. The same was true for lake trout, whether or not they matured eggs and were stripped. Total body residues reported by Allison et al. for the highest feedings of DDT appear to approximate those found in the eggs as reported in this paper. Methods of determination were different since they used paper chromatography. It appears that there may be a variation in description of the time of mortality in relation to feeding. In the New York studies, feeding was considered to begin at the general swim-up of fry when, according to hatchery procedure, the fish are assumed to be ready to feed and feeding is started. In DDT-affected

fish, it is doubtful that the fish do feed. Terminology used by Allison et al. appears to indicate that they considered the sac fry period as ended when the fry began to feed. If this means a period when most of the fry are observed to be feeding, it can represent an overlap of the two periods as considered in the present paper.

Macek (1968) apparently included mortality at the time of absorption of triglyceride fats with the sac fry mortality. In the present study, feeding (i.e., swim-up) was considered to occur while the fry still retain yolk and before they may actually commence general feeding. Thus, time schedules probably do not coincide.

It has been determined, on the basis of controlled experimentation in hatchery waters not subject to extraneous contaminants which might additively or directly affect salmonid reproduction, that DDT fed in sufficient quantity over sufficiently extended periods can adversely affect the reproductive efficiency of brown trout and brook trout. The major effect occurs in the period following swim-up during and after the time when absorption of triglyceride fats begins. It has also been confirmed that DDT fed to lake trout, at a rate even below the levels found in basic food from a natural water where reproduction has been affected, has an exactly similar effect under controlled conditions where no other contaminants able to produce such conditions can be present.

LITERATURE CITED

ALLISON, DON, BURTON J. KALLMAN, OLIVER B. COPE AND CHARLES C. VANVALIN. 1963. Insecticides: effects on cutthroat trout of repeated exposures to DDT. Science 142:958-961.

_____ 1964. Some chronic effects of DDT on cutthroat trout. U.S. Bur. Sport Fish. and Wildl., Res. Rep. 64.

BURDICK, G. E., E. J. HARRIS, H. J. DEAN, T. M. WALKER, JACK SKEA AND DAVID COLBY. 1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Am. Fish. Soc. 93(2):127-136.

BURDICK, G. E., E. J. HARRIS, H. J. DEAN, T. M. WALKER, JACK SKEA AND DAVID SWEENEY. 1968. Methoxychlor as a blackfly larvicide, persistence of its residues in fish and its effect on stream arthropods. N. Y. Fish and Game Jour. 15(2):121-142.

MACEK, KENNETH J. 1968. Reproduction in brook trout (*Salvelinus fontinalis*) fed sublethal concentrations of DDT. Jour. Fish. Res. Bd. of Canada 25 (9):1787-1796.

SNEDECOR, GEORGE W. 1956. Statistical Methods, 5th ed. Iowa State Coll. Press, Ames, Iowa.

BLOOD PARASITES OF WILD TURKEYS IN NEW YORK [1]

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ABSTRACT

Blood smears from 115 wild turkeys (*Meleagris gallopavo*) from New York State were examined for blood parasites, and six (5.2 per cent), all from Cattaraugus County, were found to be parasitized. One was parasitized with *Leucocytozoon smithi,* three with *Haemoproteus meleagridis* and two with both organisms. The infections were light, and no evidence of pathogenicity was found. Other parasites specifically searched for but not found were trypanosomes, *Plasmodium* and microfilariae. This is believed to be the first report of *L. smithi* and *H. meleagridis* in this State, and the possible significance of such infections to wild and domestic turkeys is discussed.

Wild turkeys (*Meleagris gallopavo*) are becoming increasingly important in New York, not only as game birds, but also because of their historic and aesthetic values. Cattaraugus and Allegany Counties, which border on Pennsylvania's McKean and Potter Counties, have the largest wild turkey populations in the State. Wild turkeys moved into this region in the late 1940's and became established as a natural range extension from Pennsylvania (Eaton, 1964). Due to the movement of this southwestern New York population, and because of trapping and transfer operations, turkeys are now established in parts of central New York, the Catskills and Fulton County in the peripheral Adirondacks.

If wild turkeys are to be managed, it is essential that mortality factors be determined. Little is known about the incidence and importance of parasites in the species in general, and nothing is known about its parasites in New York. This paper deals with the incidence of blood parasites in wild turkeys in New York and their potential importance to wild and domestic stock. Following is a brief summary of the nature of the two organisms encountered.

Leucocytozoon smithi was first described by Laveran and Lucet (1905) from domestic turkeys in France, and it is believed to occur only in turkeys. Parasites of this genus are found only in birds. The name was based on the belief that the gametocytes parasitize only

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blood leucocytes, but Cook (1954) and Desser (1967) showed that they develop in cells of the erythrocytic series as well.

Black flies have been found to be the vectors of *L. smithi* (Skidmore, 1932; Richey and Ware, 1955; Byrd, 1959; Wehr, 1962). Schizonts have been found in the hepatic cells of domestic turkeys (Newberne, 1955; Wehr, 1962). Very young gametocytes have not been observed, but older gametocytes are found in erythrocytes (Byrd, 1959; Wehr, 1962).

Leucocytozoon smithi was described as causing disease in domestic turkeys by Stephan (1922), Skidmore (1932), Travis et al., (1939), West and Starr (1940), Banks (1943), Hinshaw and McNeil (1943), Savage and Isa (1945), Stoddard et al., (1952) and Bierer et al. (1959). In the instance described by Skidmore, only 40 poults remained at the end of the summer out of an original flock of 385. Savage and Isa reported that a Canadian turkey raiser lost 5,000 of his 8,000 turkeys, supposedly to *L. smithi*. Symptoms in young domestic turkeys may be seen for only one or two days before death. Sick domestic turkeys lose their appetite, appear depressed and have a tendency to lie down a great deal. Frequently, the birds have been observed to fall over, gasp a few times and die. Infections in adult domestic turkeys are less severe and there may be no obvious symptoms, although the birds may become anemic and emaciated (Hagen and Bruner, 1957).

Mosby and Handley (1943) reported *L. smithi* in wild turkeys in Virginia. Kozicky (1948) found *Leucocytozoon* in five wild turkeys in Pennsylvania, and McDowell (1954) reported it in wild turkeys in Virginia. Byrd (1959) found *L. smithi* in nine free-ranging adult wild turkeys examined but not in nine juveniles, all from the vicinity of Cumberland State Forest in Virginia.

Blood parasites of the genus *Haemoproteus* have sausage-shaped gametocytes that contain pigment granules and occur in red blood cells. In 1938, an infection was observed in a half-grown domestic turkey from Texas (Morehouse, 1945). In the District of Columbia, one of four domestic turkeys was found infected (Wetmore, 1941). In South Carolina, 10 domestic turkeys were found parasitized in one instance (Atchley, 1951), and 22 of 52 examined in another flock showed the parasite in blood smears (Bierer et al., 1959). Morehouse thought that a heavy *Haemoproteus* infection might have been pathogenic to an anemic domestic turkey.

Haemoproteus was first reported in wild turkeys by Kozicky (1948) who found five of 97 examined in Pennsylvania in 1947 to be infected, although four of the five had been reared in captivity. Love et al. (1953) found one of two wild turkeys in Georgia to be infected. In Texas, Cook et al. (1966) found all of 63 juvenile wild turkeys and 63 per cent of 70 adults to be lightly infected with *Haemoproteus*

meleagridis. The development, means of transmission and pathogenicity of *H. meleagridis* in wild turkeys is unknown (Cook, 1971, pp. 291-308).

MATERIALS AND METHODS

In New York, blood smears were collected in 1969, 1970 and 1971 from wild turkeys handled during banding and telemetry studies under Federal Aid in Fish and Wildlife Restoration Project W-81-R or submitted to the Wildlife Research Laboratory for postmortem studies. They were fixed in aboslute methyl alcohol and stained with Giemsa stain. The stained specimens were studied microscopically, being first scanned under low power (100×) and then examined for a minimum of 20 minutes under oil immersion (960×).

Blood from 115 free-ranging wild turkeys (Table 1) was examined for blood parasites, 93 of the specimens coming from Cattaraugus County where the collections were distributed over an approximately 575-square-mile area considered representative of the best turkey range

TABLE 1. DISTRIBUTION OF WILD TURKEYS FROM WHICH BLOOD SMEARS WERE TAKEN FROM CATTARAUGUS COUNTY

County	Year and month	Adult		Juvenile		Total
		Male	Female	Male	Female	
Cattaraugus	1969 September	2	4	12	11	29
	1970 August-September	..	13	20	30	63
	1971 March	..	..	..	1	1
Cortland	1971 May	..	1	..	..	1
Fulton	1970 March	..	1	2	3	6
	1971 March	..	4	2	3	9
Sullivan	1970 August	..	3	..	..	3
	October	..	2	..	..	2
Tompkins	1971 May	1	..	..	..	1
Total		3	28	36	48	115

in the State. The 15 specimens from Fulton County were from a small new and isolated turkey population established by transferring wild-trapped birds from Delaware and Cattaraugus Counties in 1964 and 1966, respectively. Juvenile turkeys were distinguished by the technique of Knoder (1959).

RESULTS

Of the 115 wild turkeys examined, six (5.2 per cent) harbored blood parasites. *Leucocytozoon* and *Haemoproteus* infections were present, but no trypanosomes, *Plasmodium* or microfilariae were found.

All the parasitized birds came from Cattaraugus County (Table 2) where the incidence was 6.5 per cent.

TABLE 2. INCIDENCE OF BLOOD PARASITES IN BLOOD SMEARS FROM WILD TURKEYS FROM CATTARAUGUS COUNTY

Year	Number examined	Incidence of parasites		Nature of infection in individual birds			
				Bird		Infection	
		Number	Per cent	Sex	Age (weeks)	Organism	Parasitemia (per 10,000 red blood cells)
1969	29	1	3.4	Male	17	Leucocytozoon	2
1970	63	5	7.9	Male	15	Haemoproteus	1
				Female	15	Haemoproteus	1
				Female	15	Haemoproteus	120
				Female	15	Leucocytozoon Haemoproteus	50 30
				Female	15	Leucocytozoon Haemoproteus	1 3
1971	1	0	..	Female	(juv.)	..	..
Total	93	6	6.5				

The taxonomic characteristics of the *Leucocytozoon* and *Haemoproteus* organisms found in the blood smears from these wild turkeys were consistent with *L. smithi* and *H. meleagridis* as described by Levine (1961) and Biester and Schwarte (1965). This appears to be the first finding of these parasites in turkeys in New York.

The morphology and staining properties of the erythrocytes of the parasitized turkeys were normal, and there was no indication of anemia. No observations on internal pathology were made, since all the parasitized birds were part of a banding and release program. However, the birds were in good flesh and showed no outward signs of disease.

DISCUSSION

Blood parasites did not seem important as pathogens in the 115 wild turkeys from which blood smears were taken. This was evidenced by the low incidence of *Leucocytozoon* and *Haemoproteus* and the relatively low levels of parasitemias. However, the majority of blood smears in this study were obtained from birds that were healthy enough to travel with a flock or brood at the time they were trapped. Sick, inactive birds were unlikely to have been trapped, and dead

turkeys are rarely found in time for necropsy. In addition, all the blood smears came from birds that were 15 or more weeks old. According to Hagen and Bruner (1957) *L. smithi* is thought to affect primarily young turkeys, mostly those under 12 weeks of age.

Byrd (1959) thought that the *Leucocytozoon* he found in Virginia was probably an innocuous organism to wild turkeys. However, he reported natural *Leucocytozoon* infections in white holland poults that caused emaciation, prostration and death. At necropsy, the poults with the highest parasitemias exhibited hemorrhaging in the intestinal mucosa and some hypertrophy of the liver and spleen. No infections, other than the *Leucocytozoon,* were found. Poults that recovered became carriers and failed to gain weight as fast as the turkeys that were not parasitized by *Leucocytozoon*. Byrd suggested the possibility that wild turkeys may have greater resistance to *L. smithi* than have domestic turkeys. Perhaps the physiological changes associated with domestication have made domestic turkeys more susceptible to leucocytozoonosis. As suggested by Johnson et al. (1938) with respect to *L. smithi,* and by Bierer et al. (1959) with respect to *Haemoproteus,* wild turkeys may act as reservoirs of infection for domestic turkeys.

As telemetry techniques are improved, wild turkeys may be acquired in a moribund state or shortly after death. Then information on the morbidity and mortality factors affecting them can be more readily obtained, and the importance of *L. smithi* and *H. meleagridis* may be clarified. If the wild turkey population in New York expands and increases in density, the incidence and importance of parasites may also increase.

One of the black fly vectors, *Prosimulium hirtipes,* is widespread in New York State (Stone and Jamnback, 1955). They reported that in the Adirondacks it makes up 80 per cent of the larval population during winter and early spring. The peak period of adult emergence was between May 15 and May 30 in 1950, 1951 and 1952. The adults live for about 3 weeks. This would seem to indicate that high populations of this vector would be available to transmit *L. smithi* to young poults in the Adirondack region if the parasite is, or becomes, present among wild turkeys there.

Much less is known about the biology of *H. meleagridis* than is known about *L. smithi.* Because it is present in wild turkeys and was thought to be pathogenic in a domestic turkey (Morehouse, 1945), both its life cycle and its role as a potential pathogen need to be studied more fully. Furthermore, since both organisms are present among wild turkeys in Cattaraugus County, and both have been reported as turkey pathogens, there is need for further information on the incidence of these blood parasites.

LITERATURE CITED

ATCHLEY, F. O. 1951. *Leucocytozoon andrewsi* n. sp. from chickens observed in a survey of blood parasites in domestic animals in South Carolina. Jour. Parasitol. 37:483.

BANKS, W. C. 1943. *Leucocytozoon smithi* infection and other diseases of turkey poults in central Texas. Jour. Am. Vet. Med. Assoc. 102:467.

BIERER, B. W., C. L. VICKERS AND J. B. THOMAS. 1959. A parasitism in turkeys due to a hemoproteus-like blood parasite. Jour. Am. Vet. Med. Assoc. 135(3):181-182.

BIESTER, H. E., AND L. H. SCHWARTE. 1965. Diseases of Poultry. Iowa State Univ. Press, Ames, Iowa.

BYRD, M. S. 1959. Observations on *Leucocytozoon* in pen-raised and free-ranging wild turkeys. Jour. Wildl. Mgt. 23:145.

COOK, A. R. 1954. The gametocyte development of *Leucocytozoon simondi*. Proc. Helminthol. Soc. 21:1.

COOK, R. S. 1971. Infectious and Parasitic Diseases of Wild Birds. Iowa State Univ. Press, Ames, Iowa.

COOK, R. S., D. O. TRAINER AND W. C. GLAZENER. 1966. *Haemoproteus* in wild turkeys from the coastal bend of South Texas. Jour. Protozool. 13:588.

DESSER, S. S. 1967. Schizogony and gametogony of *Leucocytozoon simondi* and associated reactions in the avian host. Jour. Protozool. 14:244.

EATON, S. W. 1964. The wild turkey in New York State. Kingbird. 14(1):4-11.

HAGEN, W. A., AND D. W. BRUNER. 1957. The Infectious Diseases of Domestic Animals. Comstock Publishing Associates, Ithaca, N. Y.

HINSHAW, W. R., AND E. MCNEIL. 1943. *Leucocytozoon* sp. from turkeys in California. Poultry Sci. 22:268.

JOHNSON, E. P., G. W. UNDERHILL, J. A. COX AND W. L. THRELKELD. 1938. A blood protozoan of turkeys transmitted by *Simulium nigroparvum* (Twinn). Am. Jour. Hyg. 27(4):649-665.

KNODER, E. 1959. An aging technique for juvenile wild turkeys based on the rate of primary feather moult and growth. Proc. First Nat'l Wild Turkey Sympos. :159-176.

KOZICKY, E. L. 1948. Some protozoan parasites of the eastern wild turkey in Pennsylvania. Jour. Wildl. Mgt. 12:263.

LAVERAN, A., AND A. LUCET. 1905. Deux hematozoaires de la perdrix et au dindon. C. R. L'Acad. Sci. 141(18):673-676.

LEVINE, N. D. 1961. Protozoan Parasites of Domestic Animals and Man. Burgess Pub. Co., Minneapolis, Minn.

LOVE, G. J., S. A. WILKIN AND M. H. GOODWIN, JR. 1953. Incidence of blood parasites in birds collected in southwestern Georgia. Jour. Parasitol. 39:52.

MCDOWELL, R. D. 1954. Unpublished report to the Virginia Commission of Game and Inland Fisheries. (Filed in Va. Comm. Game and Inland Fish. Office, Richmond, Va.)

MOREHOUSE, N. F. 1945. The occurrence of *Haemoproteus* sp. in the domesticated turkey. Trans. Am. Microscop. Soc. 64:109.

MOSBY, H. S., AND C. O. HANDLEY. 1943. The Wild Turkey in Virginia: its status, life history, and management. Virginia Comm. Game and Inland Fisheries.

NEWBERNE, J. W. 1955. The pathology of *Leucocytozoon* infection in turkeys with a note on its tissue stages. Am. Jour. Vet. Res. 16:593.

RICHEY, D. J., AND R. E. WARE. 1955. Schizonts of *Leucocytozoon smithi* in artificially infected turkeys. Cornell Vet. 45:642.

SAVAGE, A., AND J. M. ISA. 1945. An outbreak of *Leucocytozoon* disease in turkeys. Cornell Vet. 35:270.

SKIDMORE, L. V. 1932. *Leucocytozoon smithi* in turkeys and its transmission by *Simulium occidentale* Townsend. Zentr. Bakteriol. Parasitenk. Abt. I. Orig. 125:329.

STEPHAN, J. 1922. Uber eine durch *Leucocytozoen* verusacht Gänse Und Putenerkrankung. Deutsch. tierärztl. Wochenscher. 30:589.

STODDARD, E. D., J. T. TUMLIN AND D. E. COOPERRIDER. 1952. Recent outbreak of *Leucocytozoon* infection in adult turkeys in Georgia. Jour. Am. Vet. Med Assoc. 121:190.

Stone, A., and H. A. Jamnback. 1955. The black flies of New York State. New York State Museum, Bull. 349.

Travis, B. V., M. H. Goodwin, Jr. and E. Gambrell. 1939. Preliminary note on the occurrence of *Leucocytozoon smithi* Laveran and Lucet (1905) in turkeys in the southeastern United States. Jour. Parasitol. 25:278.

Wehr, E. E. 1962. Studies on leucocytozoonosis of turkeys, with notes on schizogony, transmission, and control of *Leucocytozoon smithi*. Avian Dis. 6:195.

West, J. L., and L. E. Starr. 1940. Further observations on a blood protozoan infection in turkeys. Vet. Med. 35:649.

Wetmore, P. W. 1941. Blood parasites of birds of the District of Columbia and Patuxent Research Refuge vicinity. Jour. Parasitol. 27:379.

TRACE METALS IN NEW YORK STATE FISH [1]

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ABSTRACT

An analytical survey was conducted of the concentrations of eight metals in fish from 11 New York State waters. Analysis of barium, cadmium, cobalt, nickel, silver, tin, vanadium and zinc in fish was performed by spark source mass spectrometry following dry ashing of samples. Barium, cadmium and silver were present in the range of 0.1 ppm. Tin and zinc were usually found at relatively higher levels of 0.5 to several ppm. Cobalt, nickel and vanadium were intermediate in concentration being most often less than 1 ppm.

Although trace metals in marketed foods have long been a concern to regulatory agencies, it is largely because of the discovery of widespread mercury contamination that other metals are now suspect as possible environmental pollutants. The sources of metal contamination in aquatic systems include domestic and municipal sewage, industrial and mineral wastes, radioactive effluents, cooling and irrigation water, agricultural chemicals and air-borne dust. Metals may exert their toxicity in living organisms by enzyme poisoning, precipitation, chelation or catalytic degradation of essential metabolities, altering the selective permeability of cell membranes and replacing chemically similar metals having essential structural, metabolic or electrochemical functions (Water Quality Criteria, 1968, p. 85). In fish, metals may also coagulate external mucus, thus interfering with respiration, salt balance and metabolic secretion of waste products (Carpenter, 1927).

Several metals about which concern has been voiced are of interest because of their toxicity and also possible essentiality. Cadmium levels in the air of 28 American cities have been closely correlated with the incidence of death from hypertension and arteriosclerotic heart disease (Carroll, 1966). Cadmium concentrations have also been reported to

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be higher in kidney tissue of subjects dying of hypertensive diseases (Schroeder, 1965). Rats dosed with cadmium show hypertensive behavior, and drugs which relieve hypertension also chelate cadmium strongly. The possible hazards of environmental barium are unknown, but its presence as an additive in diesel fuel at concentrations up to 1,500 ppm is of concern (Miner, 1969). Zinc is protective against the toxic action of several other elements such as cadmium (Schroeder et al., 1967). Zinc intake of Americans has decreased since it is not readily absorbed by plants and galvanized pipes are much less used for domestic plumbing. Zinc is higher in the blood of Americans in the northeastern United States probably owing to air pollution (Kubota et al., 1968). Vanadium may be useful in controlling blood cholesterol levels (Lewis, 1959). A deficiency of vanadium in the diet of chickens resulted in poor feather development, and its addition to the diet of rats produced a 40 per cent growth promotion (Schwarz and Milne, 1971). When nickel was deficient in the diet of chickens it resulted in the production of thickened legs, enlarged hocks and orange-colored skin (Nielson and Higgs, 1971). Finally, tin may be essential owing to its growth-promoting effect as demonstrated in rats (Schwarz, 1971).

In the work reported, a cooperative project with the New York State Conservation Department was undertaken to survey game fish from several waters of the State for a number of metals of current interest such as those discussed above.

PROCEDURE

The fish were netted in 1969 and 1970 by Department personnel, and their species, sex, length and weight were recorded. All fish were decapitated and eviscerated. The remainder was ground in a food chopper, thoroughly mixed and frozen in polyethylene bags prior to analysis. Ten grams of each fish sample were ashed at 500° C. overnight. The ash was dissolved in 10 milliliters of 0.8N hydrochloric acid. The solution was analyzed by spark source mass spectrometry using sodium molybdate as an internal standard. Up to 0.2 milliliter of the solution was evaporated on a tip of gold wire using an infrared lamp. The deposited material was then sparked against a second gold electrode. During analysis a low pulse length and repetition rate was employed to avoid overheating the electrodes and, therefore, minimize thermal ionization.

RESULTS

Table 1 lists the species of fish collected in the survey. Statistics of the fish sampled, including location of netting, sex, length and weight, are given in Table 2. The approximate locations of the waters

TABLE 1. COMMON AND SCIENTIFIC NAMES OF THE FISH ANALYZED

Common name	Scientific name
Black crappie	*Pomoxis nigromaculatus*
Carp	*Cyprinus carpio*
Chain pickerel	*Esox niger*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Northern pike	*Esox lucius*
Smallmouth bass	*Micropterus dolomieui*
Striped bass	*Morone saxatilis*
Sturgeon	*Acipenser* sp.
Walleye	*Stizostedion v. vitreum*
White sucker	*Catastomus commersoni*
Yellow perch	*Perca flavescens*

Figure 1. Approximate location of the waters from which the fish analyzed were taken. Numbers refer to the waters as listed and named in Table 2.

from which the fish were netted are shown in Figure 1. The concentrations of metals found are given in Table 3. A few general observations are apparent from these data. Barium, cadmium and silver concentrations were quite consistently low. Tin, and particularly zinc, levels in the fish were high. Cobalt, nickel and vanadium concentrations were intermediate. The high levels of zinc in fish may reflect the cor-

TABLE 2. STATISTICS OF FISH SAMPLED FROM NEW YORK STATE WATERS IN 1969 AND 1970 FOR METAL ANALYSIS

Tag number	Water *	Date	Species	Sex	Length (centimeters)	Weight (kilometers)
Cay-1	Cayuga Lake (1)	1969	Chain pickerel	..	..	..
Cay-2	"	"	"	..	..	..
Cay-3	"	"	"	..	..	..
3CL-1	"	"	Largemouth bass	Male	31.7	0.621
3CL-2	"	"	"	..	15.25	..
3B-3578	Lake Champlain (Cumberland Bay) (3)	8-12-70	Largemouth bass	Female	30.8	0.515
5A-3547	"	"	Northern pike	Male	61.5	1.375
3B-3614	"	"	"	Female	47	0.575
5A-3561	Lake Champlain (Cumberland Bay) (3)	8-13-70	Walleye	Male	45	0.925
3B-3883	Lake Champlain (Willsboro Bay) (4)	8-20-70	Walleye	Male	32.4	0.300
2-Chg1#2	Chautauqua Lake (5)	1970(?)	Black crappie	..	..	..
2F-1215(HgF-3250)	"	9-28-70	Largemouth bass	Female	29.9	0.355
2F-1212(HgF-3247)	"	"	Muskellunge	Female	98.4	5.815
2F-1214(HgF-3249)	"	"	Smallmouth bass	Female	43.8	1.480
2F-1216	"	"	Walleye	Male	56.5	1.505
F 662(R.P.L.)	Lake Delta (6)	8-18-70	Northern pike	Female	92.8	4.975
F 613(R.P.L.)	"	"	Smallmouth bass	..	40	1.150
F 614(R.P.L.)	"	"	"	Male	33.6	0.565
F 608(R.P.L.)	"	"	Walleye	Female	57	1.645
F 609(R.P.L.)	"	"	"	Female	48.9	1.070
2F-2314(HgF-209)	Lake Erie (Dunkirk) (7)	11-19-70	Northern pike	Female	78	3.610
2F-1210(HgF-210)	"	9-27-70	Walleye	Male	53.3	1.485
2F-1322(HgF-226)	"	10- 8-70	"	Male	51.3	1.245
2F-1414(HgF-425)	Lake Erie (Silver Creek) (8)	11- 3-70	Walleye	Male	34.8	0.455

4-4L-10	Fourth Lake (9)	1969	Lake trout	Male	37.8	0.497
4-4L-11	"	"	"	..	..	..
4-4L-12	"	"	"	Female	55.9	1.872
4-4L-23	"	"	White sucker	Male	29.2	0.301
8-Hud-R-3	Hudson River (10)	1969	Striped bass	Male	43.7	0.985
G-789(HF3097)	Lake Ontario (11)	9-30-70	Northern pike	Female	55.9	1.125
4RA2631	Lake Ontario (Pt. Peninsula) (12)	1970(?)	Smallmouth bass	Female	34.8	0.758
4RA2641	"	"	"	Female	38	1.054
4RA2642	"	"	"	Female	38.7	1.035
6R9723(HgF-194)	Sacandaga Reservoir (13)	9-9-70	Smallmouth bass	..	31.8	0.450
6R9788(HgF-201)	"	"	"	..	34.4	0.625
6R9708(HgF-178)	"	"	Walleye	Male	33.6	0.400
6R9716(HgF-180)	"	"	"	Male	43.2	0.710
6R9717(HgF-181)	"	"	"	..	44.5	0.770
6R-9150(R.P.L.)	Saratoga Lake (14)	1970(?)	Carp	Female	55.9	2.36
6R-9148(R.P.L.)	"	"	Northern pike	Female	81.8	3.09
6R-9149(R.P.L.)	"	"	Smallmouth bass	Male	44.5	1.32
6R-9151(R.P.L.)	"	"	Walleye	Female	55.5	1.77
6R-9152(R.P.L.)	"	"	Yellow perch	Female	31.8	0.543
101S14	St. Lawrence River (15)	1969	Muskellunge	Male	77.5	3.832
2-St-L-4	"	"	Smallmouth bass	Male	26.9	0.280
3-SLS-6	"	"	Sturgeon	Male	73.5	2.430
4-Mas-1	St. Lawrence River (Massena) (16)	1969	Walleye	..	..	..
1-St.L-Hg-4	St. Lawrence R. (Old Man Is.) (17)	1969	Walleye	..	..	..

* Numeral in parentheses indicates location of water as shown in Figure 1.

Table 3. Concentration (ppm fresh weight) of Metals in Fish

Tag Number	Water	Barium	Cadmium	Cobalt	Nickel	Silver	Tin	Vanadium	Zinc
Cay-1	Cayuga Lake	0.05	0.05	0.32	0.25	0.03	4.1	0.32	6.5
Cay-2	"	0.05	0.13	0.07	0.13	0.03	0.48	0.21	4.4
Cay-3	"	0.05	0.06	0.13	0.10	0.01	0.17	0.13	3.1
3CL-1	"	0.05	0.05	0.29	0.25	0.01	0.55	0.18	0.9
3CL-2	"	0.05	0.10	0.95	1.9	0.01	0.90	0.95	18
3B-3578	Lake Champlain	0.05	0.08	0.35	0.43	0.03	3.6	0.13	6.5
5A-3547	"	0.05	0.13	0.24	0.39	0.04	0.65	0.25	4.6
3B-3614	"	0.07	0.08	0.21	0.60	0.02	0.80	0.45	13
5A-3561	"	0.10	0.15	0.14	0.12	0.04	0.46	0.14	2.6
3B-3883	"	0.10	0.05	0.11	0.25	0.04	0.46	0.24	7.5
2-Chgl#2	Chautauqua Lake	0.05	0.05	0.08	0.13	0.02	0.25	0.10	2.9
2F-1215	"	0.05	0.05	0.15	0.18	0.02	0.70	0.65	10
2F-1212	"	0.05	0.05	1.7	1.3	0.02	1.1	0.65	38
2F-1214	"	0.05	0.05	0.26	0.27	0.02	6.0	0.80	9.5
2F-1216	"	0.12	0.14	4.7	3.8	0.03	17	2.4	14
F-662	Lake Delta	0.05	0.05	0.16	0.23	0.29	0.55	0.07	4.3
F-613	"	0.05	0.07	1.6	1.0	0.02	3.1	0.80	12
F-614	"	0.05	0.12	0.31	0.50	0.03	0.95	0.33	10
F-608	"	0.05	0.11	0.32	0.37	0.03	1.6	4.7	6
F-609	"	0.05	0.05	0.31	0.48	0.02	0.05	0.50	4.0
2F-2314	Lake Erie	0.12	0.14	4.7	3.8	0.03	17	2.4	14
2F-1210	"	0.16	0.10	0.34	0.65	0.05	1.1	0.17	11
2F-1322	"	0.26	0.15	0.23	0.42	0.04	2.5	0.30	9.5
2F-1414	"	0.25	0.10	0.48	0.95	0.03	20	1.2	17
4-4L-10	Fourth Lake	0.06	0.10	0.06	0.12	0.03	0.70	0.05	1.4
4-4L-11	"	0.05	0.10	0.42	0.07	0.07	0.23	0.19	1.5
4-4L-12	"	0.10	0.05	0.10	0.27	0.65	0.80	0.41	9.0
4-4L-23	"	0.05	0.05	0.34	0.09	0.11	1.5	2.9	3.3
8-Hud-R-3	Hudson River	0.05	0.05	0.13	0.13	0.03	0.90	0.09	2.6
G-789	Lake Ontario	0.05	0.08	0.43	0.41	0.02	2.0	0.55	9.5
4RA2631	"	0.07	0.05	0.75	0.60	0.06	0.75	0.27	4.3
4RA2641	"	0.05	0.05	0.17	0.55	0.01	2.2	0.08	7.5
4RA2642	"	0.05	0.05	1.1	1.2	0.01	2.0	0.41	4.6
6R9723	Sacandaga Reservoir	0.10	0.11	0.16	0.16	0.03	0.43	0.26	3.9

6R9788	"	0.10	0.09	0.28	0.19	0.02	1.8	0.12	3.8
6R-9708	"	0.05	0.05	0.11	0.30	0.03	0.85	0.33	7.0
6R-9716	"	0.10	0.17	0.10	0.21	0.03	0.44	0.18	3.1
6R-9717	"	0.05	0.04	0.09	0.17	0.01	0.19	0.10	1.8
6R-9150	Saratoga Lake	0.10	0.14	0.03	0.04	0.03	0.15	0.09	2.6
6R-9148	"	0.05	0.06	0.17	0.28	0.01	0.06	0.07	1.2
6R-9149	Saratoga Lake	0.05	0.05	0.20	0.42	0.03	0.65	0.40	4.8
6R-9151	"	0.07	0.06	0.09	0.17	0.02	0.90	0.19	6.5
6R-9152	"	0.07	0.11	0.27	0.26	0.03	0.75	0.24	7.5
101SL4	St. Lawrence River	0.22	0.05	0.33	0.19	0.03	0.55	0.07	1.8
2-St-L-4	"	0.11	0.08	0.04	0.23	0.03	0.05	0.29	2.0
3-SL-56	"	0.22	0.06	0.13	0.03	0.03	0.60	0.17	5.0
4-Mas-1	"	0.07	0.05	0.12	0.19	0.01	0.38	0.08	5.5
1St.L-Hg-4	"	0.06	0.06	0.10	0.39	0.01	0.55	0.05	7.5

Table 4. Metal Concentrations in Certain New York Waters *

Metal	Range of concentration (ppb)		
	Hudson River	St. Lawrence River	Lake Erie
Barium	11-52	16- 35	12- 35
Cadmium	1	..	3- 12
Cobalt	1- 5	..	2- 4
Nickel	..	5- 10	..
Silver	..	1- 6	..
Zinc	8-93	4-210	20-423

* Data generalized from Kopp and Kroner (1967) and Durum et al. (1970).

respondingly high range of zinc concentrations in water (Table 4). In a survey of this type of a limited number of fish, it is not possible to assuredly explain unusually high levels of particular elements in specific fish. It is possible that what appear to be strangely high levels of certain metals in some fish are related to local sources of water pollution by the metals from industry or natural mineral sources. Given species of fish may also be accumulators of specific elements.

In conclusion, the trace concentrations of cadmium and silver which are normally considered toxic elements would appear to constitute no hazard to consumers. Based on current information regarding the known or probable essentiality of cobalt, nickel, tin, vanadium and zinc, the levels of these metals found in the fish are probably very desirable from a nutritional standpoint, especially if present in forms which are readily assimilated when fish are consumed.

LITERATURE CITED

Carpenter, K. E. 1927. The lethal action of soluble metallic sales on fishes. Jour. Exp. Zool. 4:378-390.

Carroll, R. E. 1966. The relationship of cadmium in the air to cardiovascular disease death rates. Jour. Am. Med. Assoc. 198:177-179.

Durum, W. H., J. D. Hem and S. G. Heidal. 1970 Reconnaissance of selected minor elements in surface waters of the United States, October 1970. Geol. Survey Circ. 643. U.S. Geological Survey, Washington, D.C.

Kopp, J. F., and R. C. Kroner. 1967. Trace metals in waters of the United States. U.S. Dept. Int., Fed. Water Pollution Control Admin., Cincinnati, Ohio.

Kubota, J., V. A. Lazar and F. Losee. 1968. Copper, zinc, cadmium and lead in human blood from 19 locations in the United States. Arch. Environ. Health 16:788-793.

Lewis, C. E. 1959. The biological actions of vanadium. Am. Med Assoc. Arch. Ind. Health 19:419-425.

Minor, S. 1969. Air pollution aspects of barium and its compounds. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. :14-15.

Nielsen, F. H., and D. J. Higgs. 1971. Further studies involving a nickel deficiency in chicks. In: Trace Substances in Environment Health IV (D. D. Hemphill, ed.): 241-246. Univ. Missouri, Columbia, Mo.

Schroeder, H. A. 1965. Cadmium as a factor in hypertension. Jour. Chron. Dis. 18:647-656.

Schroeder, H. A., A. P. Nason, I. H. Tipton and J. J. Balassa. 1967. Essential trace metals in man: Zinc. Relation to environmental cadmium. Jour. Chron. Dis. 20:179-210.

SCHWARZ, K. 1971. Tin as an essential growth factor for rats. In: Newer Trace Elements in Nutrition (W. Mertz and W. E. Cornatzer, ed.):313-326. Marcel Dekker, Inc., New York.

SCHWARZ, K., AND D. B. MILNE. 1971. Growth effects of vanadium in the rat. Sci. 174:426-428.

WATER QUALITY CRITERIA. 1968. Report of the National Technical Advisory Committee to the Secretary of the Interior. U.S. Government Printing Office, Washington, D.C.

BIOLOGY AND MANAGEMENT OF SMALLMOUTH BASS IN ONEIDA LAKE, NEW YORK

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ABSTRACT

Age composition and growth rate of smallmouth bass in Oneida Lake were determined from scales and measurements collected from 1952 to 1970. Dominant year classes were produced in years when mean June air temperatures were above normal. The catch of young bass in seine hauls indicated that year-class size was established by August, but the causal relation between June air temperature and year-class survival was not established.

The long-term average growth rate of bass was stable between 1949 and 1966, but annual growth increments varied markedly. Much of this variation was attributable to differences in mean summer air temperatures and the abundance of young yellow perch which were an important forage species.

Annual survival and minimum rates of exploitation were determined from tag returns reported by anglers. The mean annual survival during a 14-year period was 0.57 which agreed closely with estimates from catch curves. A linear regression was fitted to annual survival rates and minimum rates of exploitation to obtain an estimate of natural mortality. The intercept in the event of no fishing corresponded to a natural mortality rate of 0.125. The role of regulations and stocking in the management of the population is examined.

The smallmouth bass (*Micropterus dolomieui*) population in Oneida Lake has supported an intensive sport fishery for over 50 years. Adams and Hankinson (1928) in a review of the early fishery observed "conditions (except overfishing) seem to be especially favorable for smallmouth bass and every effort should be made to maintain this highly desirable species." Although the fishing pressure has probably increased, the smallmouth remains second only to the walleye as a sport fish. Grosslein (1961) estimated the annual catch ranged from 17,000 to 31,000 in 1957 to 1959.

Studies of adult smallmouth bass were begun in 1954 by New York State Conservation Department biologists and were continued from 1956 to 1970 by Cornell University as a part of a broader study of Oneida Lake supported by Federal Aid funds (Project F-17-R, New York). The general objective was to provide information on life history which would be of value in managing the population. This paper describes the growth and mortality rates and evaluates the effects of some environmental factors on reproduction and growth of smallmouth bass.

Tagging from 1954 to 1959 demonstrated that there were numerous subpopulations of smallmouth bass with small but consistent differences in growth rate (Forney, 1961). Two of these subpopulations were studied intensively. The Shackelton Point population inhabited the broad rocky littoral zone bordering Shackelton Point on the southern shore of the lake. The Constantia population occupied a group of rocky shoals along the northwestern shore. These populations were

separated by 7 miles of open water and migration between the areas was rare.

Smallmouth bass, walleye (*Stizostedion vitreum*) and yellow perch (*Perca flavescens*) are the most important sport fish. Pan fish are abundant and pumpkinseed (*Lepomis gibbosus*), rock bass (*Ambloplites rupestris*) and white perch (*Morone americana*) are frequently associated with smallmouth bass. Largemouth bass (*Micropterus salmoides*) are common but they are generally restricted to weedy coves while smallmouth bass occupy the exposed littoral areas.

Oneida Lake is a shallow, eutrophic lake in central New York. About 26 per cent of its 79.8-square mile area is less than 14 feet deep (Greeson and Meyers, 1969) and most bass are concentrated in this littoral zone. The bottom, beyond the beaches, consists of rubble interspersed with areas of sand. There is a gradual transition to mud at depths of 12 to 18 feet.

Most of the shoreline is exposed to vigorous wave action and, perhaps because of this, smallmouth bass spawn in deep water. The only smallmouth bass nests observed during this study were found by SCUBA divers at depths of 14 to 18 feet. From observations of a few nests and the degree of maturation of ovaries examined in the spring, it is estimated that spawning occurs from late May to mid-June. Young bass first appear along the beaches in mid- to late June. Although the density of young is probably highest in shallow water, some young-of-the-year bass are caught in trawls fished at depths of 15 to 20 feet.

GENERAL METHODS

Bass were collected in trap nets or by electrofishing in May. Nets were set at six to ten locations within a 1-mile radius of Constantia annually from 1954 to 1965. Bass taken in these nets were used for hatchery brood stock, and the fish were tagged in mid-June immediately before they were returned to the lake. At Shackelton Point, bass were collected by trap-netting in 1957 and 1958 and by electrofishing in subsequent years. Electrofishing was restricted to the same 3-mile section of shoreline from 1959 to 1969, and bass were tagged and released where captured.

All bass were tagged with a monel metal strap, 2¼ x ⅛ in size, which loosely encircled the mandible. This type of tag tends to reduce the growth of bass (Youngs, 1958) but the tag is retained for many years. Erosion of the mandible was seldom evident even in fish recovered 8 to 10 years after tagging. Most tags were recovered by anglers, and the return of tags was encouraged through frequent publicity releases and personal contact. Self-addressed tag return envelopes were available at public boat-launching sites and private boat liveries.

Age and growth of the population was determined from scales and measurements taken at the time of tagging. Total length was measured to the nearest tenth inch. Scale markings were usually distinct, and the validity of the annulus as a year mark was verified in an earlier study (Forney, 1961). Calculated lengths were determined from a linear regression with an intercept of 1.62 inches. Growth computations were based on bass of ages IV through X. Younger age groups were excluded because they were not fully vulnerable to capture, and annuli of older fish were too difficult to identify. Tagged recaptures were not used in determining growth since the tag may have retarded growth.

Abundance of young bass was estimated from the catch in seine hauls made at weekly or more frequent intervals from July through mid-September at nine sites within a 2-mile radius of Shackelton Point. The number of young in standardized hauls with a 75-foot ¼-inch-mesh bag seine generally increased during July, reached a peak in August and declined in the fall. The mean catch per seine haul in August was used as an index of year-class size.

REGULATION OF YEAR-CLASS SIZE

Strong year classes of bass have appeared at irregular intervals during the past two decades. In the 1950's, dominant year classes were produced in 1952, 1954 and 1959, while the 1962, 1963 and 1964 year classes were the strongest observed in the 1960's. The pattern of strong and weak year classes was similar at Shackelton Point and Constantia as shown by the relative contribution of year classes at age IV to the catch between 1958 and 1966 (Tables 1 and 2). Evidently the factors causing variation in year-class size were common to both populations.

Table 1. Percentage Age Composition of Smallmouth Bass Netted Near Constantia in May from 1954 to 1966

Year	Number aged	Percentage in each age group							
		III	IV	V	VI	VII	VIII	IX	X and older
1954	127	0.8	5.5	40.9	40.9	7.9	2.4	0.8	0.8
1955	52	32.7	19.2	7.7	15.4	21.2	1.9	0.0	1.9
1956	270	0.4	73.7	5.9	4.1	7.0	7.8	0.7	0.4
1957	286	0.7	20.3	64.7	3.8	2.4	3.5	3.5	1.0
1958	230	2.2	24.3	19.1	43.5	3.0	2.2	1.7	3.9
1959	0	...	...	...	...	...	...	...	...
1960	293	8.2	7.2	19.8	17.7	18.1	24.2	2.7	2.0
1961	383	0.0	58.7	8.1	11.2	8.6	6.5	5.5	1.3
1962	322	3.4	3.1	58.7	6.5	3.1	5.9	4.3	3.7
1963	282	0.4	68.4	3.1	20.9	1.8	1.4	1.4	2.6
1964	317	1.3	20.2	65.0	3.5	7.2	1.6	0.6	0.6
1965	329	0.0	19.1	21.6	47.4	2.1	6.7	1.5	1.5
1966	313	0.9	21.1	37.7	15.0	21.1	1.3	1.9	0.9

Table 2. Percentage Age Composition of Smallmouth Bass Collected at Shackelton Point in May from 1958 to 1970

Year	Number aged	Percentage in each age group							
		III	IV	V	VI	VII	VIII	IX	X and older
1958	184	11.4	24.4	22.3	24.4	3.3	2.2	1.6	10.3
1959	97	0.0	29.9	21.6	15.5	25.8	1.0	4.1	2.0
1960	197	32.0	11.2	23.8	17.2	9.6	3.0	1.0	2.0
1961	267	1.8	68.5	6.7	6.0	7.1	3.7	4.5	1.5
1962	266	51.1	4.5	34.2	4.1	0.4	2.3	1.1	2.3
1963	390	14.4	55.7	3.3	21.5	2.6	1.3	1.3	0.3
1964	258	22.9	31.0	30.6	4.6	7.8	1.6	0.8	0.8
1965	227	8.8	34.4	31.3	17.2	1.8	2.6	1.3	2.6
1966	341	2.0	38.4	32.2	14.1	9.1	1.7	1.5	0.9
1967	333	1.2	12.3	41.4	26.7	8.7	6.6	0.9	2.1
1968	352	1.7	4.3	12.5	39.2	23.9	11.1	4.8	2.6
1969	325	17.8	5.3	10.7	12.0	28.1	15.0	8.5	2.6
1970	243	9.9	44.0	4.5	6.2	5.3	18.1	7.4	4.5

Table 3. Total Number of Young Smallmouth Bass in Seine Hauls at Nine Stations Near Shackelton Point in August from 1959 to 1969

Year	Station									Number of hauls	Number of bass per haul
	1	2	3	4	5	6	7	8	9		
1959	5	6	28	8	5	11	6	1	21	36	2.53
1960	3	1	10	3	1	7	2	1	14	36	1.17
1961	9	17	39	3	3	13	8	32	18	45	3.16
1962	34	38	59	15	3	26	18	29	55	36	7.69
1963	0	0	2	1	0	5	4	1	2	36	0.42
1964	0	0	0	1	0	1	0	0	0	45	0.04
1965	0	0	0	2	0	0	0	0	1	36	0.08
1966	8	5	11	16	7	24	18	27	19	54	2.50
1967	21	12	13	5	7	40	15	23	64	36	5.56
1968	1	0	0	0	0	2	1	0	1	36	0.14
1969	1	0	6	3	4	1	10	9	14	36	1.33

Differences in year-class size at Shackelton Point were established early in the first year of life. The mean catch of young bass in seine hauls during August was high in 1959, 1961, 1962 and 1966 (Table 3) and these same year classes were relatively abundant at age IV. Rankings of the 1959 to 1966 year classes, classified according to abundance of young and contribution to the electrofishing catch (Table 2), did not exactly correspond but the correlation was high ($r_c = 0.81$, $P < .05$). The most noticeable discrepancy was the high density of young in 1961 and 1962 compared with the modest contribution of these year classes to the catch at age IV. This could be evidence of compensatory mortality at high densities, but indices of abundance are not sufficiently precise to define the exact relation between abundance of young and recruitment to the fishery.

Relation of Adult Stock to Abundance of Young

The population of adult bass near Shackelton Point was fairly stable between 1960 and 1969 (Table 4). Abundance was determined by tagging age III and older bass collected along a 3-mile section of shoreline in May, and the population was estimated from the ratio of

Table 4. Relative Abundance of Adult Smallmouth Bass at Shackelton Point from 1960 to 1969, Estimated from Tag Recoveries

Year	Number tagged (age III and older)	Catch in following year (age IV and older)		Estimated population
		Total	Recaptures	
1960	250	388	9	10,800
1961	381	159	9	6,700
1962	313	404	14	9,000
1963	448	360	15	10,800
1964	312	336	8	13,100
1965	349	497	19	9,100
1966	473	483	28	8,200
1967	437	401	29	6,000
1968	358	443	22	7,200
1969	461	343	21	7,500

tagged to unmarked bass age IV and older in the catch the following spring. Computed population size is a valid index of abundance, but estimates are probably inflated by emigration and migration between the mark and recapture periods.

A relation between adult stock in May and the abundance of young in August was not evident in examining data for the years 1960 to 1969. Considering the narrow range in size of the adult population and the large fluctuations in abundance of young, lack of a discernible relation was not surprising. Attempts to relate egg production estimated from population size, age distribution and fecundity to the abundance of young were equally unsuccessful (data not shown). Although estimates of the adult population are crude, it is obvious that parental stock during the period of study was less important than post-spawning mortality in determining the number of young in late summer.

Relation of Temperature to Abundance of Young

The temperature regime during and following spawning has been frequently cited as a factor regulating early survival of fish although supporting evidence is not conclusive (Swallow, 1968). The abundance of young bass in August from 1959 to 1969 (Table 3) was compared with the air temperatures recorded at the U. S. Weather Bureau Station at Hancock Field (9 miles southwest of Oneida Lake) for evidence of climatic effects on reproduction. Monthly temperature averages

were calculated from daily means of the maximum and minimum temperatures recorded. A close positive correlation was found between the abundance of young bass and the mean June temperature, but temperatures in May and July showed a negative correlation (Table 5). The fact that most bass nest in June and their eggs hatch during this month might explain the correlation with June temperatures if the earliest stages of development are the most sensitive to temperature.

The age composition of the smallmouth bass catch at Constantia provided supporting evidence that strong year classes were generally produced in years when June temperatures were above normal. The relative abundance of the year classes produced in the years 1950 to 1962 was estimated from their percentage contribution to the catch

Table 5. Abundance of Young Smallmouth Bass in August and Mean Monthly Air Temperatures in May, June and July from 1959 to 1969 *

Year	Number of bass (from Table 3)	Mean air temperature		
		May	June	July
1959	2.53	60.0	67.6	73.5
1960	1.17	59.8	66.6	69.4
1961	3.16	55.5	66.6	71.8
1962	7.69	62.3	68.3	69.2
1963	0.42	54.7	66.6	71.7
1964	0.04	61.6	66.0	73.2
1965	0.08	59.4	63.7	67.5
1966	2.50	51.2	65.7	71.1
1967	5.56	50.2	69.5	67.7
1968	0.14	53.6	64.9	69.9
1969	1.33	55.7	64.5	69.9

* Rank correlation: number of bass vs. May temperature -0.10
number of bass vs. June temperature -0.72
number of bass vs. July temperature -0.08

Table 6. Relative Contribution of the 1950 to 1962 Year Classes of Smallmouth Bass to the Catch at Constantia and Mean Air Temperature in the Year of Hatching

Year class *	Percentage contribution at age IV	Mean air Temperature
1950	5.5	65.7
1951	19.2	65.5
1952	73.7	67.3
1953	20.3	67.7
1954	24.3	68.4
1956	7.2	67.0
1957	58.7	70.4
1958	3.1	62.5
1959	68.4	67.6
1960	20.2	66.6
1961	19.1	66.6
1962	21.1	68.3

* No data available for 1955 year class at age IV because no bass were collected in 1959

at age IV (Table 6). Strength of the year classes produced during the 1950's was strongly correlated ($r_c = 0.75$) with June air temperatures. Thus during two decades there was a consistent relation between air temperature regime and smallmouth bass survival.

Fry and Watt (1955) compared year-class strength of smallmouth bass in Manitoulin Island waters (Lake Huron) with regional air temperatures and found that the best correlation was with the algebraic sum of monthly deviations for the period from July through October. In Oneida Lake, only June temperatures showed a strong positive correlation with year-class strength of bass, and various combinations of monthly temperature indices for July through October were low or negative. The lakes studied by Fry and Watt were near the northern limit of smallmouth bass range, and low temperatures throughout the growing season may limit early survival. In Oneida Lake water temperatures of 70° to 80° F. during the summer may be near or above optimum, and survival in exceptionally warm years might be reduced rather than enhanced.

Difficulties in observing nesting and early development of smallmouth bass precluded detailed studies needed to identify the causal relation between temperature and early mortality. Water temperatures in late May were usually 55° to 60° F. rising to the high 60's by late June. Daily temperature fluctuations seldom exceeded 2 degrees at depths of 12 to 18 feet where most nests were located. Since normal development of eggs can occur within this temperature range (Webster, 1948), direct mortality of embryos from high or low temperature is unlikely.

June temperature regimes which were favorable for smallmouth bass reproduction also enhanced survival of largemouth bass and rock bass which spawn at about the same time. The mean number of young

Table 7. Catch of Young Largemouth Bass and Rock Bass in Weekly Seine Hauls at Nine Stations During August and Mean Air Temperatures from 1959 to 1969 *

Year	Catch per haul		Mean air temperature
	Largemouth bass	Rock bass	
1959	1.86	2.69	67.6
1960	0.75	1.39	66.6
1961	1.44	5.07	66.6
1962	0.53	3.89	68.3
1963	0.44	3.47	66.6
1964	0.07	1.07	66.0
1965	0.47	1.67	63.7
1966	1.20	2.11	65.7
1967	2.42	8.19	69.5
1968	0.75	0.47	64.9
1969	0.08	2.58	64.5

* Rank correlation: largemouth bass vs. temperature 0.53, $P<.05$
rock bass vs. temperature 0.68, $P<.05$

largemouth bass and rock bass caught in seine hauls from 1960 to 1969 at Shackelton Point were correlated with June temperatures (Table 7). The similar response shown by the three species implies that thermal effects are not highly specific and must act over a period of several weeks since smallmouth bass, largemouth bass and rock bass do not spawn at exactly the same time and their rates of egg and fry development are not identical. Possibly temperature is causally related to food density, intensity of predation or other factors which indirectly affect early mortality of all three species.

GROWTH

The growth rates of bass at Constantia and Shackelton Point were nearly identical as shown by the mean calculated lengths at ages I to X (Table 8). Under the existing 10-inch minimum size limit most bass were recruited into the fishery during their third and fourth growing seasons. Growth of Oneida Lake bass was substantially better than that reported for two other New York waters, Cayuga Lake (Webster, 1954) and eastern Lake Ontario (Stone et al., 1954), but slower than that of bass in Norris Reservoir in Tennessee (Stroud, 1948).

Long-term Growth Trends

Growth data for fish collected at Constantia and Shackelton Point were pooled, and the annual length increments (Table 9) were examined for evidence of growth trends during the period from 1948 to 1969. Linear regressions were fitted to first-, second-, third-, fourth-, fifth- and sixth-year increments with year as the dependent variable. Slope values for all regressions were low and did not differ significantly from zero.

Major changes in the composition of the fish population and in benthic fauna occurred during the period between 1948 to 1969. The emerald shiner (*Notropis antherinoides*) population had historically supported a large bait fishery in Oneida Lake, but this population collapsed in the late 1950's. Experimental gill net catches from 1957 to 1969 suggested a substantial decrease in channel catfish, burbot and white bass, while white perch, which invaded the lake in about 1951, became one of the predominate species in later years (Alsop and Forney, 1962). The burrowing mayfly (*Hexagenia limbata)* which was abundant during the early 1950's had nearly disappeared by the mid-1960's (Jacobsen, 1966).

The ecological changes did not have a measurable effect on the average growth rate of the smallmouth bass. Either growth of bass was rather insensitive to changes in abundance of associated species or changes in species composition had compensatory effects on growth.

Table 8. Mean Calculated Lengths at Successive Annuli for Smallmouth Bass Collected at Constantia from 1954 to 1965 and at Shackelton Point from 1958 to 1969

Location	Number of fish	Annulus									
		1	2	3	4	5	6	7	8	9	10
Constantia	2,699	3.71	6.75	9.77	12.18	13.65	14.71	15.57	16.24	16.74	17.19
Shackelton Point	2,565	3.67	6.87	9.84	12.16	13.60	14.62	15.38	16.02	16.42	16.88
Unweighted mean	5,264	3.69	6.81	9.80	12.17	13.62	14.66	15.48	16.13	16.58	17.04

TABLE 9. ANNUAL LENGTH INCREMENTS (IN INCHES) OF SMALLMOUTH BASS IN ONEIDA LAKE AND DATA ON AIR TEMPERATURES AND ABUNDANCE OF YOUNG YELLOW PERCH FROM 1948 TO 1969

Calendar year	Year of life										Air temperature (°F.) *	Young yellow perch §
	1	2	3	4	5	6	7	8	9	10		
1948	3.59	3.15	..	..	..	..	..	..	..	..	67.7	..
1949	3.70	3.32	3.39	..	..	..	..	..	..	..	70.2	
1950	3.51	2.48	2.32	2.02	..	..	..	..	..	..	66.0	
1951	3.51	2.73	2.80	2.33	1.48	..	..	..	..	..	66.4	
1952	3.67	3.41	3.15	2.94	2.11	1.31	..	..	..	..	68.9	
1953	3.44	3.21	2.82	2.43	1.51	0.87	0.59	..	..	..	68.3	
1954	3.80	3.02	3.16	2.53	1.93	1.26	0.91	..	..	..	67.2	
1955	4.00	3.63	3.50	2.85	1.73	1.37	0.80	0.57	..	..	70.3	
1956	3.72	2.75	2.34	1.64	0.79	0.91	0.75	0.44	0.18	..	65.8	
1957	3.84	3.13	3.21	2.66	1.97	1.34	1.08	0.75	0.77	..	67.6	..
1958	3.70	2.84	2.68	2.18	1.35	1.00	0.62	0.58	0.58	0.30	66.0	..
1959	4.39	3.08	3.41	2.33	1.68	1.11	0.72	0.56	0.49	0.48	70.6	0.44
1960	3.70	3.20	3.11	2.41	1.70	0.99	0.69	0.46	0.30	0.36	67.1	4.81
1961	3.57	3.00	2.96	2.33	1.38	1.09	0.68	0.49	0.34	0.33	69.6	2.22
1962	3.60	3.15	3.12	2.34	1.58	1.00	0.83	0.52	0.49	0.40	66.6	7.48
1963	3.75	2.90	2.81	2.14	1.14	0.82	0.51	0.48	0.48	0.10	65.4	3.12
1964	3.15	3.30	3.35	2.67	1.76	1.05	0.61	0.52	0.40	0.34	67.1	7.29
1965	3.39	3.09	2.78	2.34	1.48	1.01	0.68	0.42	0.51	..	65.8	2.43
1966	3.63	3.10	2.79	2.15	1.26	0.80	0.56	0.39	..	0.28	66.6	0.91
1967	..	3.38	3.26	2.47	1.69	1.11	0.77	0.59	0.40	..	66.1	4.39
1968	..	..	3.25	2.65	1.87	1.17	0.87	0.66	0.53	0.40	67.1	9.32
1969	..	..	..	2.17	1.32	0.91	0.72	0.44	0.21	0.17	67.5	0.44
Unweighted mean	3.67	3.09	3.01	2.38	1.56	1.06	0.73	0.52	0.44	0.32	xxx	xxx

* June-September.
§ Pounds per trawl haul.

Annual Variation in Growth

Growth increments varied markedly from year to year, and generally fish of different ages showed similar deviations from the average in a calendar year (Table 9). For example, increments in 1952 were greater than those in 1953 for fish of a corresponding age and consistently greater in 1955 than in 1956 for fish of all ages. However, there are many inconsistencies particularly in comparing growth of young and age I fish with growth of older bass in the same year. Failure of all age groups to show the same trends from year to year indicates a difference in response of young and old bass to factors regulating growth.

Growth of all age groups appeared to be better in warm summers. Annual length increments from the first to sixth year showed a strong positive relation to mean air temperature from June through September (Table 10). Coefficient of determination values (R^2) indicate that 18 to 41 per cent of the annual variation in growth of various age

Table 10. Equations, *F* Values and Coefficients of Determination for Linear Regressions of Length Increments of Smallmouth Bass (Y) in the First Through Sixth Years of Life on Mean Air Temperature (X)

Year of life	Equation	*F* value	Coefficient (R^2)
1	$Y = -1.359 + 0.0744X$	5.28*	0.237
2	$Y = -2.511 + 0.0833X$	6.02*	0.251
3	$Y = -5.776 + 0.1303X$	12.51**	0.410
4	$Y = -4.492 + 0.1020X$	6.67*	0.270
5	$Y = -4.337 + 0.0876X$	3.63	0.176
6	$Y = -2.882 + 0.0585X$	5.96*	0.271

* Significant at .05 level.
** Significant at .01 level.

Table 11. Percentage Frequency of Occurence of Food Items in Stomachs of Smallmouth Bass from Oneida Lake

Food item	Age group			
	0+	I+	II+	III+ and older
Fish				
Yellow perch	0	22	30	22
White perch	0	2	5	4
Log perch	0	0	2	2
Walleye	0	2	0	1
Sunfish	0	2	2	2
Unidentified	3	32	30	15
Crayfish	0	24	62	67
Amphipods	52	22	0	4
Zooplankton	34	2	0	0
Insects	42	5	0	6
Number with food	28	50	52	142
Number examined	33	70	82	261

Table 12. Equations, F Values, and Coefficients of Determination for Linear Regressions of Length Increments of Smallmouth Bass (Y) on Abundance of Young Yellow Perch (X_1) and Mean Air Temperature (X_2)

Length increment	Equation	F value	Coefficient (R^2)
1st	$Y = -1.66 - 0.0563X_1 + 0.0810X_2$	2.81	0.484
2nd	$Y = 1.773 + 0.0349X_1 + 0.0183X_2$	1.72	0.330
3rd	$Y = -3.605 + 0.0503X_1 + 0.0964X_2$	5.82*	0.592
4th - 6th	$Y = -2.12 + 0.0467X_1 + 0.05314X_2$	10.02**	0.690

* Significant at .05 level.
** Significant at .01 level.

groups may be attributable to temperature. Coble (1967) found a similar growth-temperature relation for smallmouth bass in South Bay (Manitoulin Island) but there was no demonstrable relation between temperature and growth of bass in Lake Opeongo. He suggested that the limited food supply in Lake Opeongo might suppress any response to annual variation in temperature.

Fish were important in the diet of all age groups of bass in Oneida Lake except young-of-the-year (Table 11), and young perch comprised a high proportion of the identifiable remains in stomachs examined. Abundance of young perch was highly variable from 1959 to 1969 (Forney, 1971) and the average catch of young in trawls towed at four locations at weekly or more frequent intervals during August and September ranged from 0.44 to 9.32 pounds (Table 9).

The relation between abundance of young perch, mean temperature and growth increments of bass was examined by multiple linear regression. Partial regression coefficients indicated that high perch density and temperature contributed to an increase in growth increments of age I and older bass from 1959 to 1969 (Table 12). The R^2 values show that these two factors may have accounted for 69 per cent of the annual variation in growth increments of ages IV to VI bass. The negative relation between perch abundance and growth of young bass suggests the possibility of competition since young of both species feed on small invertebrates.

MORTALITY RATES

Mortality components were determined from tag recoveries reported by anglers from 1954 to 1969. The value of data derived from tag recoveries is marred by the possibilities that tagged fish are more or less vulnerable to recapture than unmarked fish, experience higher mortality or tag loss or are not representative of the unmarked population with respect to size and age. Unfortunately only a few of these potential errors can be evaluated.

The age distribution of bass released at the beginning of the

Table 13. Age Distribution of Smallmouth Bass Tagged at Shackelton Point and Constantia from 1960 to 1968 and Age Distribution of Those Recaptured during the Fishing Season Following Release

Group	Age					
	III	IV	V	VI	VII	Older
Released						
Number	403	1489	1170	698	325	321
Per cent	9.1	33.8	26.6	15.8	7.4	7.3
Recaptured						
Number	55	206	130	97	29	35
Per cent	10.0	37.3	23.6	17.6	5.1	6.4

fishing season was compared with that of bass recaptured during the open season, and the pooled data for 1960 to 1968 are shown in Table 13. Homogeneity of the release-recapture ratios for different age groups recovered in each year were tested individually. Chi-square values were not significant indicating that all age groups tagged were probably equally vulnerable to angling. Thus, failure to tag age groups in proportion to their abundance in the population would not bias estimates of fishing mortality from tag returns.

Temporary effects of tagging on vulnerability can usually be detected by comparing the seasonal distribution of tag recoveries of fish released at the beginning of the fishing season with recoveries of fish which have been at large a year or more. Bass were generally tagged at Shackelton Point in early May. Recoveries of bass tagged just prior to the fishing season and recoveries of bass which had been at large a year or more show the same seasonal pattern (Table 14). A high proportion of both groups was recovered in the first 15 days of the season. Similarly, tagged bass released at Constantia in early June, 2 to 3 weeks before the season opened, from 1955 to 1958 were recovered in about the same proportions during bimonthly periods as bass released in earlier years. However, beginning in 1959, the bass season opened on June 16 and only 1 to 7 days elapsed between tagging and the opening day. Recoveries in June of bass released at Constantia immediately before the fishing season from 1960 to 1966 were much lower than those of bass which had been at large a year or more. Recoveries of bass tagged at Constantia from 1960 to 1966 were not used in estimating mortality rates since these bass were not fully vulnerable to angling at the beginning of the season.

Tag loss was not measured, but the recovery of some tagged bass 8 to 10 years after release suggests that the rate of loss was low. The tag rarely caused erosion of the mandible and irritation of tissue was seldom observed. No mortality was observed during or immediately following tagging.

Survival rates were estimated from the sequence of annual re-

Table 14. Bimonthly Distribution of Tag Recoveries Reported by Anglers for Smallmouth Bass Released at the Beginning of th Fishing Season and for Those at Large a Year or More §

Location and year	Relation of recovery to time of release	Bimonthly period										Chi-square
		June	July		August		September		October		November	
		16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	
Shackelton Point 1958-1969	1st season	100 (25.4)	67 (17.0)	46 (11.7)	53 (13.4)	56 (14.2)	33 (8.4)	23 (5.6)	11 (2.8)	5 (1.3)	1 (0.2)	10.58
	Subsequent seasons	148 (30.2)	70 (15.6)	35 (7.8)	56 (12.5)	51 (11.4)	30 (6.7)	26 (5.8)	16 (3.6)	4 (0.9)	1 (0.2)	
Constantia 1955-1958	1st season		46 (19.2)	44 (18.3)	43 (17.9)	39 (16.2)	31 (12.9)	20 (8.3)	11 (4.5)	4 (1.7)	2 (0.8)	8.02
	Subsequent seasons		43 (21.7)	35 (17.7)	34 (17.2)	31 (15.6)	24 (12.1)	8 (4.0)	12 (6.1)	4 (2.0)	7 (3.5)	
Constantia 1960-1966	1st season	49 (17.8)	43 (15.6)	25 (9.0)	58 (21.0)	34 (12.3)	24 (8.7)	19 (6.9)	11 (4.0)	7 (2.5)	6 (2.2)	18.63*
	Subsequent seasons	80 (27.3)	39 (13.3)	44 (15.0)	38 (13.0)	32 (10.9)	21 (7.2)	18 (6.1)	7 (2.4)	9 (3.1)	5 (1.7)	

* Test of homogeneity of ratios significant at .05 level.
§ Figures in parentheses represent percentage of tag recoveries in each case.

Table 15. Number of Smallmouth Bass Tagged Near Constantia in June, Number of Recaptures Reported by Anglers and Estimates of Exploitation and Survival

Year tagged	Number tagged	Recaptures																Rate of exploitation	Annual survival
		1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969		
1954	828	114	49	54	8	8	5	6	5	0	1	0	0	0	0	0	0	0.138	0.491
1955	514	..	94	57	7	4	5	2	2	0	1	0	0	0	0	0	0	0.183	0.536
1956	499	..	..	107	10	9	17	7	7	0	3	0	0	0	0	0	1	0.214	0.398
1957	350	..	..	..	16	16	32	17	11	4	2	0	1	1	0	0	1	0.046	0.751
1958	193	..	..	..	..	11	22	14	4	3	0	0	0	0	0	0	0	0.057	.
1959	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1960	314	..	..	..	..	..	..	46	31	7	9	1	0	0	0	0	0	0.148	*
1961	451	..	..	..	..	..	..	..	82	22	23	4	1	0	2	2	0	0.182	*
1962	365	..	..	..	..	..	..	..	..	35	27	7	9	3	0	1	0	0.096	*
1963	298	..	..	..	..	..	..	..	..	..	34	16	12	4	4	3	2	0.114	*
1964	344	..	..	..	..	..	..	..	..	..	..	30	16	15	5	7	2	0.087	*
1965	387	..	..	..	..	..	..	..	..	..	..	..	30	30	13	14	3	0.078	*
1966	315	..	..	..	..	..	..	..	..	..	..	..	..	42	21	17	9	0.133	*

* No estimate; tag recoveries biased because of change in opening date of fishing season in 1959 (see text).

Table 16. Number of Smallmouth Bass Tagged Near Shackelton Point in June, Number of Recaptures Reported by Anglers and Estimates of Annual Exploitation and Survival

Year tagged	Number tagged	Recaptures													Rate of exploitation	Annual survival
		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969		
1957	131	11	5	13	6	3	1	2	0	0	0	0	0	0	0.084	0.768
1958	181	..	9	28	7	5	1	4	0	0	0	0	0	0	0.050	0.680
1959	104	..	..	18	11	3	3	1	0	1	1	0	0	0	0.173	0.531
1960	250	..	..	..	44	15	7	6	4	0	1	0	1	0	0.176	0.472
1961	381	..	..	..	..	52	26	16	5	8	6	0	3	1	0.136	0.552
1962	313	..	..	..	..	..	30	40	6	5	7	6	1	2	0.096	0.654
1963	308	..	..	..	..	..	..	55	15	8	14	2	0	1	0.178	0.498
1964	201	..	..	..	..	..	..	..	16	15	8	4	7	5	0.080	0.750
1965	349	..	..	..	..	..	..	..	..	35	23	17	7	7	0.100	0.636
1966	473	..	..	..	..	..	..	..	..	..	58	34	14	14	0.123	0.518
1967	437	..	..	..	..	..	..	..	..	..	..	43	35	32	0.098	0.645
1968	358	..	..	..	..	..	..	..	..	..	..	..	44	34	0.123	0.554
1969	461	..	..	..	..	..	..	..	..	..	..	..	..	82	0.178	..

leases and recaptures of tagged bass shown in Tables 15 and 16. Computational procedures outlined by Robson (1963) were followed to derive annual estimates of survival for bass released at Constantia from 1954 to 1966 and at Shackelton Point from 1957 to 1969.

Estimates of annual survival ranged from 0.398 to 0.768 (Tables 15 and 16). Annual survival and minimum rates of exploitation from 1954 through 1968 were inversely correlated ($r_c = -0.89$) indicating that most of the variation in annual survival was caused by angling mortality.

The geometric mean survival for all years from 1954 to 1968 (two estimates for 1957 averaged) was 0.57. This figure agrees reasonably well with independent estimates from catch curves. Survival of age V and older bass estimated by the method of Robson and Chapman (1961) was 0.52 based on pooled age distribution of bass caught at Constantia from 1954 to 1966. The corresponding survival estimate based on bass caught at Shackelton Point from 1957 to 1969 was 0.58.

Mortality from fishing and natural causes can be separated if total mortality fluctuates in response to changes in fishing success. Widrig (1954) plotted total instantaneous mortality rates against fishing effort and estimated the instantaneous natural mortality rate when fishing effort was zero. Youngs (1972) observed that survival in the absence of fishing, the complement of natural mortality, could be estimated by plotting the survival rate against the minimum rate of exploitation from tag returns as illustrated in Figure 1. The intercept of 0.875, based on rates of survival and exploitation for bass from 1954 through 1968, corresponds to a natural mortality rate of 0.125 or an instantaneous mortality coefficient of 0.133.

The accuracy of the estimate depends on the assumption that natural mortality was constant, tagged bass were representative of the population, and the same proportion of the tagged fish caught were reported each year. The best supporting evidence for the last assumption is the distribution of points along the regression line. If the proportion of tags reported declined during the study, which might be expected if angler interest decreased, exploitation would be underestimated but estimates of survival would not be affected. When graphed, the points in later years of study would tend to fall below the regression line. Since this did occur it is concluded that the proportion of tags reported did not consistently decline, although the variation around the regression line may be due in part to variation in the proportion of tags reported.

Watt (1959), in a detailed analysis of the smallmouth bass population of South Bay (Manitoulin Island) estimated that the natural instantaneous mortality coefficient for age V fish was 0.56. Latta (1963) calculated the survival and exploitation rates for a population of small-

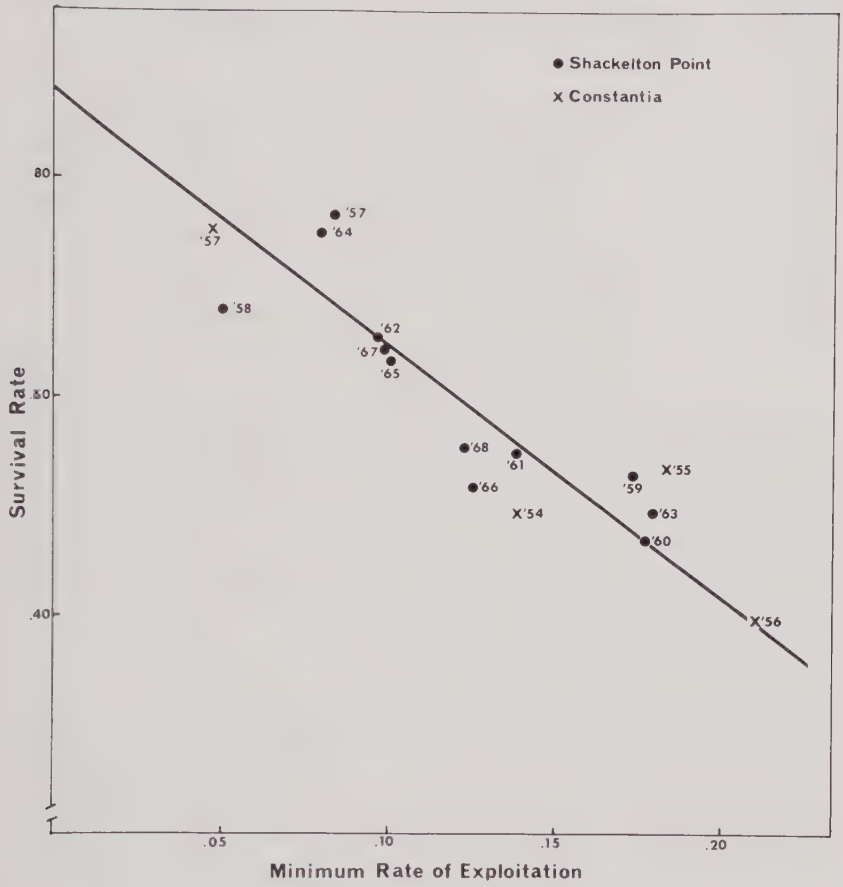

Figure 1. Annual survival rates and minimum exploitation rates from 1954 to 1968 estimated from recaptures of tagged smallmouth bass released at Shackelton Point and Constantia. Intercept of regression on vertical axis estimates survival in the absence of fishing.

mouth bass in Lake Michigan and by subtraction determined that the expectation of death from natural causes was 0.36. This corresponds to an instantaneous natural mortality coefficient of 0.54. Values for both these populations are much higher than those observed in ponds stocked with smallmouth bass. Buck and Thoits (1970) found that the annual mortality of ages II and III bass in unfished, 1-acre ponds was generally less than 10 per cent even in overcrowded conditions where growth was poor. Obviously, published data do not provide a basis for accepting or rejecting the natural mortality coefficient of 0.133 calculated for smallmouth bass in Oneida Lake. The smallmouth is a long-lived species and a low natural mortality seems reasonable. The

maximum life span of bass in Oneida Lake is at least 18 years, based on tag recoveries and age at tagging.

SMALLMOUTH BASS MANAGEMENT

During the period of study, the bass season, which at first opened July 1 and closed November 15, was extended to June 16 in 1959. A minimum size limit of 10 inches and bag limit of six fish was in effect continuously. The effect of these regulations was examined and the value of stocking was explored.

Extension of Bass Season

Tag return data are available for five fishing seasons with a July 1 opening date (1954-1958) and for seven seasons when the season opened June 16 (1960-1966). The seasonal distribution of tag recoveries reported by anglers show that the catch in the first 15 days of the season was generally higher than in subsequent 15-day periods regardless of whether the season opened June 16 or July 1 (Table 17).

Table 17. Recaptures of Smallmouth Bass Tagged at Constantia and Reported by Anglers During Bimonthly Periods from 1954 to 1958 and from 1960 to 1966 *

	Bimonthly period §							
	June	July		August		September		October 1-
Years	16-30	1-15	16-31	1-15	16-31	1-15	16-30	November 15
1954-1958	. .	150 (27.4)	89 (16.3)	93 (17.0)	79 (14.4)	60 (11.0)	31 (5.7)	45 (8.2)
1960-1966	80 (27.3)	39 (13.3)	44 (15.0)	38 (13.0)	32 (10.9)	21 (7.2)	18 (6.1)	21 (7.2)

* Opening of fishing season advanced from July 1 to June 16 in 1959.
§ Figures in parentheses represent percentage of recoveries in each case.

During the years 1954 to 1958, 27.4 per cent of the tagged bass caught at Constantia were taken in the first 15 days of July, and from 1960 to 1966 with a June 16 opening date 27.3 per cent of the catch was made in the first 15 days of the season (based on tagged fish at large over a year).

The seasonal distribution of tag returns indicates that the harvest of bass is high during the first two weeks of the season with either a July 1 or June 16 opening. Although in some years bass are still nesting in late June, there is no evidence bass are more vulnerable to angling in late June than in early July. Maloney et al. (1962) and Mraz (1964) studied the effect of liberalized regulations on largemouth bass in lakes and concluded that a high proportion of the season's catch was made in the first two weeks regardless of when the season opened.

Advancing the opening of the season 2 weeks might increase the annual fishing pressure and harvest, but the effect on exploitation could not be detected. The proportion of tagged bass reported by anglers averaged 12.8 per cent for five years with a July 1 opening date and 12.0 per cent from 1960 to 1966 when the season opened June 16. Although tag returns do not indicate an increase in exploitation, the large annual fluctuations in exploitation both before and after the change in regulations may obscure a relatively small 10 to 15 per cent increase in harvest which might result from a 15-day extension of the season.

Effect of Size Limits

Yield per recruit (Ricker, 1958) was computed for minimum size limits of 8, 10 and 12 inches, instantaneous fishing mortality coefficients of 0.30 and 0.40, and natural mortality coefficients of 0.10 and 0.20 (Table 18). The seasonal distribution of growth was determined from samples of bass collected in the summers of 1956 and 1967, and fishing mortality was apportioned among months using the seasonal distribution of tag returns as a guide as described by Forney (1966). Within the range of fishing and natural mortality rates examined,

Table 18. Relative Yield of Smallmouth Bass in Oneida Lake for Several Combinations of Instantaneous Natural and Fishing Mortality Coefficients and Minimum Size Limits

Mortality coefficient		Size limit (inches)		
Natural	Fishing	8	10	12
0.20	0.30	3,707	3.989	4,147
	0.40	3,721	4.049	4,321
0.10	0.30	5,225	5,887	6,555
	0.40	5,045	5,674	6,518

yield per recruit would be higher with a 12-inch minimum size limit than with the current 10-inch limit, and reducing the size limit to 8 inches would reduce yield. Optimum size limits for maximum yield were not determined since mortality estimates are imprecise and optimum limits should be approached by evaluating the effect on incremental increases in minimum size limits.

Increasing minimum size limits from 10 to 12 inches would theoretically increase yield 4 to 15 per cent (Table 18). This modest gain in yield would be accompanied by an increase in average size of bass in the catch. The greater prestige accorded larger fish by fishermen might be additional justification for a higher size limit.

An increase in minimum legal size would also reduce exploitation and result in an increase in adult stock. While there is no evidence

that present rates of exploitation of 30 to 35 per cent are excessive, a further increase in exploitation would involve some risk since the stock-recruitment relationship is unknown. Although recruitment of bass is strongly influenced by climatic factors, it would be unrealistic to assume that a reduction in spawning stock would not affect the probability of reproductive success.

Stocking

About 10,000 young smallmouth bass averaging 2.2 inches long were released along a 2-mile section of shoreline bordering Shackelton Point in September of 1964, 1965 and 1966. These hatchery fingerlings were identified by clipping the right ventral fin in 1964 and 1966 and the left ventral in 1965. The contribution of stocked fish to each year class was determined from the number of marked bass in samples collected by electrofishing near Shackelton Point from 1967 to 1970.

The ratio of marked to unmarked bass in samples of the 1964, 1965 and 1966 year classes was 0.41, 0.69 and 0.03, respectively, (Table 19).

Table 19. Number of Marked Fingerling Bass Stocked from 1964 to 1966 and Number of Marked and Unmarked Bass Observed in Samples of These Year Classes Collected from 1967 to 1970

Year class	Number stocked	Number caught							
		1967		1968		1969		1970	
		Marked	Unmarked	Marked	Unmarked	Marked	Unmarked	Marked	Unmarked
1964	9,316	5	6	12	17	16	50	3	15
1965	8,889	..	..	7	7	17	27	7	11
1966	11,360	..	..	..	..	2	90	4	107

The large number of young originating from natural reproduction in 1966 was probably responsible for the low contribution of stocked fingerlings to this year class. The catch of bass in seine hauls in August before stocking was 2.50 per haul in 1966 compared with 0.08 and 0.04 in 1964 and 1965 (Table 3). Since about the same number of fingerlings were stocked each year, the contribution of these fingerlings to the 1966 year class would be low although the number recruited to the adult population was probably comparable to that in 1964 and 1965.

Marked fish released from 1964 to 1966 comprised only 6 per cent of the electrofishing catch in 1969 and a lower percentage in 1970. Dispersal of fingerlings from the stocking area and regeneration of clipped fins may have contributed to the low recoveries of marked fish. However, it appears that massive stocking would be required to substantially increase the population density in Oneida Lake. The

value of stocking young smallmouth bass in established populations has been questioned by Watt (1959), Moen (1960) and others.

LITERATURE CITED

Adams, C. C., and T. L. Hankinson. 1928. The ecology and economics of Oneida Lake fish. N.Y.S. College of Forestry, Roosevelt Wildlife Annals 1(3,4):235-548.

Alsop, R. G., and J. L. Forney. 1962. Growth and food of white perch in Oneida Lake. N. Y. Fish and Game Jour. 9(2):133-136.

Buck, D. H., and C. F. Thoits III. 1970. Dynamics of one-species populations of fishes in ponds subjected to cropping and additional stocking. Illinois Nat. Hist. Survey Bull. 30(2):69-162.

Coble, D. W. 1967. Relationship of temperature to total annual growth in adult smallmouth bass. Jour. Fish. Res. Bd. Canada 24(1):87-99.

Forney, J. L. 1961. Growth, movements and survival of smallmouth bass (*Micropterus dolomieui*) in Oneida Lake, New York. N. Y. Fish and Game Jour. 8(2):88-105.

_____ 1966. Marking of walleyes and smallmouth bass in Oneida Lake, New York. New York Federal Aid Project F-17-R (progress report for Job I-a) N.Y.S. Cons. Dept. (multilith)

_____ 1971. Development of dominant year classes in a yellow perch population. Trans. Am. Fish. Soc. 100(4):739-749.

Fry, F. E. J., and K. E. F. Watt, 1955. Yields of year classes of the smallmouth bass hatched in the decade of 1940 in Manitoulin Island waters. Trans. Am. Fish. Soc. 85:135-143.

Greeson, P. E., and G. S. Meyers. 1969. The limnology of Oneida Lake an interim report. N.Y.S. Cons. Dept., Water Res. Comm. Report of Invest. RI-8.

Grosslein, M. D. 1961. Estimation of angler harvest on Oneida Lake, New York. Ph.D. thesis, Cornell Univ. Library.

Jacobsen, T. V. 1966. Trends in abundance of the mayfly (*Hexagenia limbata*) and chironomids in Oneida Lake. N. Y. Fish and Game Jour. 13(2):168-175.

Latta, W. C. 1963. The life history of the smallmouth bass, *Micropterus d. dolomieui*, at Waugoshance Point, Lake Michigan. Mich. Dept. Cons., Inst. Fish. Res. Bull. 5.

Maloney, J. E., D. R. Schupp and W. J. Scidmore. 1962. Largemouth bass population and harvest, Gladstone Lake, Crow Wing County, Minnesota. Trans. Am. Fish. Soc. 81:42-52.

Moen, T. 1960. Survival of stocked smallmouth in Iowa natural lakes. Iowa Fish and Game Div., Quart. Biol. Repts. 12(4):5-10.

Mraz, D. 1964. Evaluation of liberalized regulations of largemouth bass, Browns Lake, Wisconsin. Wis. Cons. Dept., Tech. Bull. 31.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada, Bull. 119.

Robson, D. S. 1963. Maximum likelihood estimation of a sequence of annual survival rates from a capture-recapture series. Jour. du Conseil Pour L'Exploration de la Mer. 370:330-335.

Robson, D. S., and D. G. Chapman. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc. 90:181-189.

Stone, U. B., D. G. Pasko and R. M. Roecker. 1951. A study of Lake Ontario-St. Lawrence River smallmouth bass. N. Y. Fish and Game Jour. 1((1):1-26.

Stroud, R. H. 1948. Growth of the basses and black crappie in Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci. 23(1):31-99.

Swallow, W. H. 1968. The relationship of incubation temperature to the mortality of fish embryos. M. S. thesis, Cornell Univ. Library.

Watt, K. E. 1959. Studies on population productivity. II. Factors governing productivity in a population of smallmouth bass. Ecol. Monog. 29:367-392.

Webster, D. A. 1948. Relation of temperature to survival and incubation of the eggs of smallmouth bass (*Micropterus dolomieu*). Trans. Am. Fish. Soc. 75:43-47.

_____ 1954. Smallmouth bass, *Micropterus dolomieui,* in Cayuga Lake. Part 1. Life history and environment. Cornell Univ. Memoir. 327.

Widrig, J. M. 1954. Method of estimating fish populations, with applications to Pacific sardine. U. S. Fish and Wildl. Serv. Bull. 94, Vol. 56:141-166.

Youngs, W. D. 1958. Effect of the mandible ring tag on growth and condition of fish. N. Y. Fish and Game Jour. 5(2):184-204.

_____ 1972. Estimation of natural and fishing mortality rates from tag recaptures. Trans. Am. Fish. Soc. 101:542-545.

CHARACTERISTICS OF A SMALL-LAKE FISHERY AS DETERMINED BY A CREEL CENSUS [1]

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ABSTRACT

A creel census was conducted on a shallow 117.5-acre warm-water lake in central New York from June 1965 to March 1968. Species recorded in the anglers' catch were: largemouth bass, chain pickerel, brown bullhead, yellow perch, pumpkinseed and black crappie. Catch and effort were estimated for shore, boat and ice fishermen. Effort ranged from 6,887 to 11,874 man hours, with shore fishermen expending the greatest effort and ice fishermen the least. Monthly and daily distribution of effort was determined. Bullheads, pumpkinseeds and perch were the fish most frequently caught by shore fishermen, while pumpkinseeds, pickerel and perch sustained the boat fishermen. Boat fishermen caught over 80 per cent of the bass taken. Perch were numerically the most important fish in the catch and comprised the bulk of the ice fishermen's catch. Ice fishermen also took a significant number of pickerel. Fish caught and released may be important in evaluating the quality of such a fishery.

A creel census was conducted from June 1965 through March 1968 as part of an investigation to determine the vital statistics of the fish population in Dryden Lake in central New York. Dryden Lake is a State-owned 117.5-acre lake in Tompkins County having a mean depth of 3.9 feet. The lake is highly eutrophic and supports a dense growth of submergent and emergent plants that, at times, covers more than half its area. Species of fish recorded in the anglers' catch were largemouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*), yellow perch (*Perca flavescens*), brown bullhead (*Ictalurus nebulosus*), pumpkinseed (*Lepomis gibbosus*) and black crappie (*Pomoxis nigromaculatus*).

The lake, located in a rural area, is undeveloped and the only public facility is a boat-launching ramp. Beds of aquatic plants restrict shore fishermen to a small segment of the shoreline from June to October, and the use of outboard motors is prohibited. A special regulation limits ice fishermen to two hand-held jigs rather than five tip-ups as are allowed on most New York lakes.

The purpose of this paper is to describe some of the characteristics of the fishery that should be useful in evaluating the recreational contribution of warm-water ponds in the State and facilitate the development of management priorities for these lakes. Knowledge of some of the characteristics of the fishery should also be of value in planning creel-census investigations of similar lakes.

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-17-R. Dr. John L. Forney gave advice and assistance in all phases of this study. William D. Youngs and William H. Swallow gave statistical advice.

METHODS

Of the species present, there were closed seasons only for pickerel and bass. The angling season for pickerel extended from May 1 to March 1 and encompassed that for bass. The creel census in 1967-68 applied to this entire period, while those in 1965-66 and 1966-67 covered only part of it (Table 1). The design of the three censuses was similar. The procedures and estimates for the 1967-68 season are given in detail.

Access to the lake was limited to a 1,000-foot section of road so it was possible to contact virtually all fishermen and determine total effort and catch during a census period. Census periods were half-day intervals from 8:00 a.m. to 2:30 p.m. and from 2:30 p.m. to approximately 1 hour after sunset (see Table 1). Interviewers contacted all fishermen at the beginning and end of the census period and also recorded the starting time of fishermen who arrived after the period began. If an angler was already present at the beginning of the period, the interviewer recorded the number of each species in his catch and asked him for an estimate of the time he began fishing and the number of fish caught and released. Fishermen leaving the lake or still fishing at the end of the census period were checked to determine the number of each species in their catch, and they were asked the number of panfish released as well as the number of legal- and sub-legal sized bass and pickerel released. Anglers still fishing at the end of an afternoon census during the open-water season were given a serially numbered postcard requesting the following information: time they stopped fishing; number of each species kept; number of each species released; and, in the case of bass and pickerel, whether they were of legal length.

The census was divided into the following categories: shore fishing, boat fishing and ice fishing, with each category stratified into weekday mornings, weekday afternoons, weekend and holiday mornings, and weekend and holiday afternoons. Estimates were also made for pre-forenoon fishing based on information obtained through interviews during the forenoon census period and for post-afternoon fishing based on postcard returns from fishermen remaining at the end of the afternoon period.

The half-days for a stratum were sequentially numbered, and the actual day on which a smapling pattern was begun was determined at random. The inclusion of holidays with weekend days prevented the occurrence of any long-term sequence of days sampled within the same category. This does not constitute a completely random sampling design, but confidence intervals should be reasonably close. The half-days for the ice-fishing census were randomly selected, but a restriction

Table 1. Segment of the Year, Hours of the Day and Total Hours During Which the Creel Census at Dryden Lake Was Carried On Each Year

Year	Season	Segment of year	Hours of day		Total hours
			"Morning"	"Afternoon"	
1965-66	Open water	June 16 - September 1	8 a.m. - 2 p.m.	2 p.m. - 8 p.m.	198
	Ice fishing	December 26 - January 1 January 10 - March 1	7 a.m. - 12 noon	12 noon - 5 p.m.	95
1966-67	Open water	May 19 - September 11	8 a.m. - 2:30 p.m.	2:30 p.m. - 9 p.m.	292.5
	Ice fishing	December 22 - March 1	7 a.m. - 12 noon	12 noon - 5 p.m.	150
1967-68	Open water	May 1 - November 10	8 a.m. - 2:30 p.m.	2:30 p.m. - 9 p.m.*	470.5
	Ice fishing	November 24 - December 6 December 16 - March 1	8 a.m. - 12:30 p.m.	12:30 p.m. - 5 p.m.	184.5

* In the fall of 1967 the length of the "afternoon" census was reduced as the day shortened; the last hour ending the census was as follows: until August 31, 9 p.m.; September 1-30, 8:30 p.m.; October 1-15, 8 p.m.; October 16-28, 7 p.m.; October 29-November 10, 6 p.m.

on the period selected was that a morning and afternoon period did not fall on the same day.

From these data the catch, effort, catch per hour, number of fishermen and length of the average fishing trip were determined for each census period. Total catch, effort and number of shore, boat or ice fishermen were estimated by averaging observations for individual census periods and multiplying by the number of days in the open water or ice-fishing category. The variance of the sample (s_h^2) was determined by (Cochran, 1963):

$$s_h^2 = \frac{1}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2$$

where $\bar{y}$ = average number of observations of the parameters to be estimated during a sample period;
y_i = individual observations on a sample day;
n = number of sample days; and
h = designates the stratum.

The variance of the $[V(\hat{Y}_h)]$ for each stratum was found by (Cochran, 1963):

$$V(\hat{Y}_h) = N_h (N_h - n_n)(\frac{s_h^2}{n_h})$$

where N = number of days in the stratum.

The 95 per cent confidence interval for each stratum was found by:

$$95\%\ CI = \hat{Y}_h \pm \left[\sqrt{V(\hat{Y})_h} \right] (t_{.05, \text{d.f.}})$$

where $\hat{Y}$ = estimate of the parameter; and
n-1 = degrees of freedom.

Assuming that covariance is equal to zero, the 95 per cent confidence interval for the summed estimates of a category of fishing was found by:

$$95\%\ CI = \Sigma \hat{Y}_h \pm \left[\sqrt{\Sigma V(\hat{Y}_h)} \right] (t_{.05, \text{d.f.}})$$

The effective degrees of freedom (n_e) for the confidence interval placed on the summed estimates was found by (Cochran, 1963):

$$n_e = (\Sigma g_h s_h^2)^2 \Big/ \Sigma \frac{g_h^2 s_h^4}{n_h - 1}$$

where

$$g_h = \frac{(N_h)(N_h - n)}{n_h}$$

Catch per hour was determined by dividing the recorded catch by the number of hours fished during a census period. The average length of a fishing trip was based only on those individuals who completed their trip during a census period.

The creel census was conducted for a smaller part of the fishing season in 1965-66 and 1966-67 than in 1967-68. In order to compensate, the data for the first two years were expanded by assuming that the seasonal distribution of effort and catch was proportional to that recorded in 1967-68. The estimates for the 1965-66 and 1966-67 seasons are intended only to give a rough idea of the effort and catch for those seasons.

PRECISION OF ESTIMATES

Fishing effort and catch were highly variable, and confidence intervals for these parameters were wide (Table 2). During a single census period, effort ranged from several days with no fishing to 50 man hours, and the catch ranged from zero to 51 of a single species. Estimates of effort are within useable limits for many management purposes, but estimates of catch would be of limited value in determining vital statistics of the fish population. The degree of precision is different depending on the parameters estimated and the category of fishing.

Another factor affecting precision is the percentage of the fishing time sampled, and more precise estimates could be obtained by increasing the number of days censused. In this study, about 13 per cent of the morning and 26 per cent of the afternoon open-water fishing time, and approximately 22 per cent of the ice-fishing time, were sampled. The census effort required for more precise estimates was determined using sample variance (s^2) determined from the Dryden Lake fishery.

Since a stratified design was used, the number of sample days for each stratum must be determined separately, and in practice it would

TABLE 2. PARAMETERS DETERMINED FOR BOAT, SHORE, NIGHT (BOTH BOAT AND SHORE) AND ICE FISHERMEN DURING THE PERIOD COVERED BY CENSUS IN THE 1967-68 FISHING SEASON *

Parameter	Boat	Shore	Night	Ice
Number of hours	2,778 (1,904-3,653)	2,956 (2,262-3,650)	399	1,117 (513-1,722)
Number of fishing trips	1,138 (816-1,460)	1,612 (1,233-1,991)	§	494 (246-742)
Average hours per trip	2.8	1.9	..	2.6
Bass				
Number removed	111 (53-169)	21 (4-49)	0	†
Catch per hour				
Removed ‡	0.058	0.006	..	†
Total °	0.244	0.060	..	0.013
Pickerel				
Number removed	361 (225-497)	43 (14-72)	0	198 (85-311)
Catch per hour				
Removed	0.127	0.015	..	0.176
Total °	0.244	0.039	..	0.239
Yellow perch				
Number removed	645 (329-961)	298 (49-570)	7	1,687 (879-2,495)
Catch per hour				
Removed	0.227	0.078	..	1.546
Total °	0.301	0.145	..	2.274
Bullhead				
Number removed	226 (34.488)	362 (73-725)	303	0
Catch per hour				
Removed	0.064	0.139	..	..
Total °	0.066	0.152	..	..
Pumpkinseed				
Number removed	297 (73-590)	238 (104-372)	22	45 (10-103)
Catch per hour				
Removed	0.138	0.079	..	0.042
Total °	0.180	0.307	..	0.050
Black Crappie				
Number removed	25 (7-57)	4 (1-10)	0	109 (24-201)
Catch per hour				
Removed	0.013	0.002	..	0.101
Total °	0.017	0.003	..	0.142

* Figures in parentheses represent confidence intervals.
§ No additional trips; night fishermen included in "boat" and "shore" groups.
† Open season for bass: mid-June to November 30.
‡ Based on hours fished during bass season only.
° Includes fish caught and kept plus those caught and released.

be prudent to increase sampling days only for those strata that make the major contribution to the parameter of interest. The number of sample days (n) required for a selected level of precision was determined by [2]:

$$n_h = \frac{4N_h^2 \; s_h^2 \; t^2}{CI^2 + 4t^2 s_h^2 N_h}$$

where CI = the desired confidence interval; and
t = Student's t-value (Snedecor, 1956) at a selected degree of confidence for the degrees freedom of the preliminary estimate.

The actual level of precision obtained by increasing the number of sample days to a determined n would be greater than the confidence interval selected because (1) a greater number of degrees of freedom would be obtained in the final census, (2) the sample variance would most likely decrease with increased sample size and (3) width of the confidence interval would be narrower for the combined strata than for each individual stratum.

The number of census days required to obtain 95 per cent confidence intervals with a variation of 10, 25 and 50 per cent from the mean were determined for different parameters and categories of fishing (Table 3). Estimates of effort are within useable limits for many purposes, at least for some strata; however, for most purposes, sampling days would have to be increased considerably for good estimates of catch. In the example for bass (Table 3), it was estimated that boat fishermen fishing during weekday mornings made the largest contribution to the catch (43 fish), but the percentage variation of the confidence interval from the mean estimate was over 100 per cent. In order to obtain a degree of precision that is desirable for many research purposes, e.g., 10 per cent variation, it would be necessary to conduct almost a complete census and to reduce variation to even 50 per cent of the mean would require sampling in excess of 40 per cent of the time.

CHARACTERISTICS OF THE FISHERY

Total fishing effort from May 1, 1967 to March 1, 1968 was 7,250 man hours or 62 man hours per acre. Of the total fishing pressure, 85 per cent occurred during the 7-month open-water season and only 15 per cent after freeze-up (Table 2). Adverse weather and the short length of winter days probably contributed to the low ice-fishing pressure. Total fishing effort in the 1965-66 and 1966-67 seasons, as estimated by

[2] Suggested by William H. Swallow of the Biometrics Unit at Cornell University.

TABLE 3. ESTIMATED NUMBER OF DAYS SAMPLING THAT WOULD BE REQUIRED TO OBTAIN CERTAIN LEVELS OF PRECISION COMPARED WITH THE NUMBER OF DAYS ACTUALLY SAMPLED AND LEVEL OF PRECISION OBTAINED

Parameter	Stratum	Number of days		Variation of confidence interval from mean (per cent)	Number of days sampling required for a percentage variation of		
		In stratum	Sampled		10	25	50
Hours	Boat, weekday afternoon	135	38	28	105	49	17
	Shore, weekday afternoon	135	38	36	115	64	25
	Shore, weekend forenoon	57	6	79	50	31	13
Largemouth bass	Boat, weekday forenoon	101	14	109	96	76	43
	Boat, weekend forenoon	44	5	256	43	40	38
Yellow perch	Ice, weekday afternoon	65	14	65	62	49	28
	Ice, weekend afternoon	29	6	106	28	24	16

TABLE 4. SUMMARY OF CHARACTERISTICS OF THE FISHERY AT DRYDEN LAKE FOR THE 1965-66, 1966-67 AND 1967-68 FISHING SEASONS *

Item	Season		
	1965-66	1966-67	1967-68
Hours fished	6,887	11,874	7,250
Fishing trips	3,037	4,559	3,244
Bass			
Removed	154	134	133
Yield §	1.31	1.14	1.13
Pickerel			
Removed	846	1,416	602
Yield §	7.20	12.05	5.12
Yellow perch			
Removed	3,363	2,787	2,636
Yield §	28.62	23.72	22.43
Bullhead			
Removed	1,357	909	890
Yield §	11.55	7.74	7.47
Pumpkinseed			
Removed	791	1,063	602
Yield §	6.73	9.05	5.12
Black Crappie			
Removed	0	5	138
Yield §	..	0.04	1.17
Catch per hour			
All fish removed	1.077	0.575	0.696
All fish caught †	1.283	1.068	0.185
Total yield §	55.41	53.74	42.54

* The estimates for the 1065-66 and 1966-67 seasons are based on expansion of the limited creel census period using the 1967-68 census data (see text).
§ Number of fish removed per acre.
† Includes fish caught and kept plus those caught and released.

expansion of the partial census conducted in these years, was 6,887 and 11,874 man hours, respectively (Table 4).

Fishing effort during the open-water period was about equally divided between boat and shore fishermen, but there were more shore fishermen. Shore fishermen fished an average of 1.9 hours compared with 2.8 hours for boat fishermen. Few anglers fished after dark. Most night fishing, estimated from postcard returns, was limited to shore-fishing for bullheads in May. Censuses during the 1965-66 and 1966-67 seasons indicated a similar distribution of fishing effort between boat and shore fishermen, but the observed length of trip was about 1 hour longer for both groups, although the period censused was shorter and was during the peak of the fishing season.

The greatest effort occurred during May, June, late December

and the first two to three weeks of January (Figure 1). The opening of the pickerel season on May 1 and the bass season in June would account for part of the high effort in these months. The spring fishery for bullhead also contributed to early peak fishing pressure. The first safe ice usually formed in mid- to late-December, and fishing effort during the winter was concentrated in late December and the first

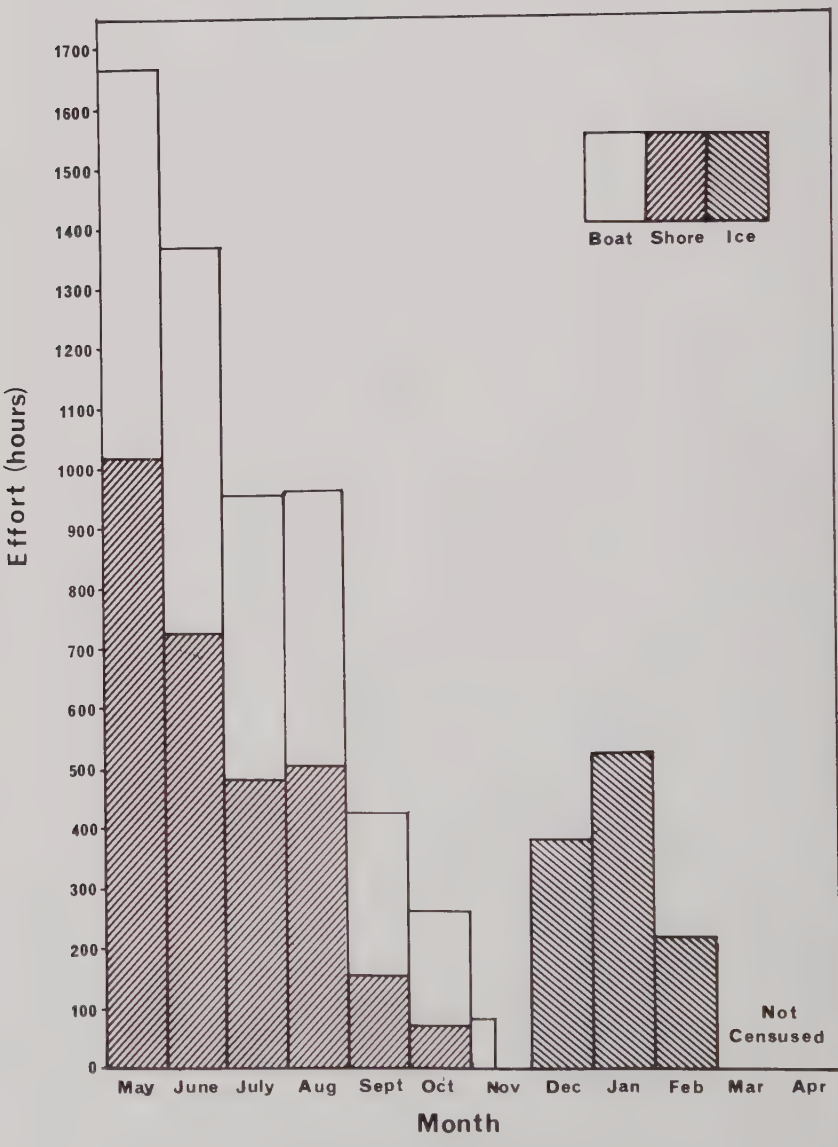

Figure 1. Distribution of fishing effort (in hours) in Dryden Lake from May 1, 1967 to March 1, 1968.

part of January. Although the winter census was terminated after the close of the pickerel season on March 1, some fishing for panfish continued until ice-out in late March to mid-April. Judging from the effort observed in early May, there was probably considerable fishing for bullheads in April, but the creel census was not conducted from March 2 through April 30.

The daily distribution of anglers is given in Figure 2 for the 1967-68 census. The distribution is given in percentage of anglers present on the hour of the total number of man hours recorded for a particular stratum of fishing (e.g., shore fishermen on weekdays). The number of hours of fishing estimated for each time and category of fishing is given in Figure 2 and includes night fishing. On weekends, most fishing occurred between 9 a.m. and 8 p.m., with the most intensive effort between 3 and 5 p.m. for shore fishermen and between 10 a.m. and 8 p.m. for boat fishermen. During weekdays, the peak effort occurred from 7 p.m. to 8 or 9 p.m. On weekdays, a higher percentage of fishing trips started earlier in the morning and more fishermen fished later in the afternoon than on weekends. Work habits were probably responsible for some early-morning fishing and the peak effort in the early evening on weekdays. Most of the fishing observed after 9 p.m. occurred during May, although an occasional fisherman remained at the end of a census period in June and July. The same daily pattern was found during other years. No differences in hourly distribution were apparent between weekdays and weekends in the ice fishery. The limitation of fewer hours of daylight and more severe weather confined most fishing to the middle of the day. The census missed individuals arriving to fish after 9 p.m. and probably a few early-morning fishermen who left the lake prior to 8 a.m.

Bullheads, pumpkinseeds and yellow perch were the species most frequently found in the catch of the shore fishermen in 1967 (Table 2). Shore fishermen had the highest catch rate and removed more bullheads than did boat fishermen, but their total catch and catch per hour was lower for other species. During the first two years of the census, shore fishermen had the highest catch and catch rate of pumpkinseeds. All species were well represented in the catch of the boat fishermen except for black crappie. Although bass made up only 4 to 7 per cent of the boat fishermen's catch, 80 to 90 per cent of the bass removed were caught by boat fishermen, and bass, along with pickerel, were the primary species sought by many of these anglers. Pumpkinseeds, chain pickerel and yellow perch were the species caught in the greatest numbers by boat fishermen.

Ice fishermen were the most successful group in terms of catch per hour and removed more fish than either boat or shore fishermen. Yellow perch comprised over 80 per cent of the ice fishermen's catch,

and ice fishing accounted for 64 per cent of the perch caught during 1968.

During the 1965-66 and 1966-67 seasons, the species composition of the catch and the numbers harvested by the three categories of fishermen were similar to those recorded in 1967-68. Bullheads, yellow perch and pumpkinseeds sustained the shore fishermen, while boat fishermen caught most of the bass and pickerel harvested during the open-water period. Ice fishing accounted for over half the perch caught each year. Ice fishermen caught 64, 18 and 33 per cent of the chain pickerel removed during the 1965-66, 1966-67 and 1967-68

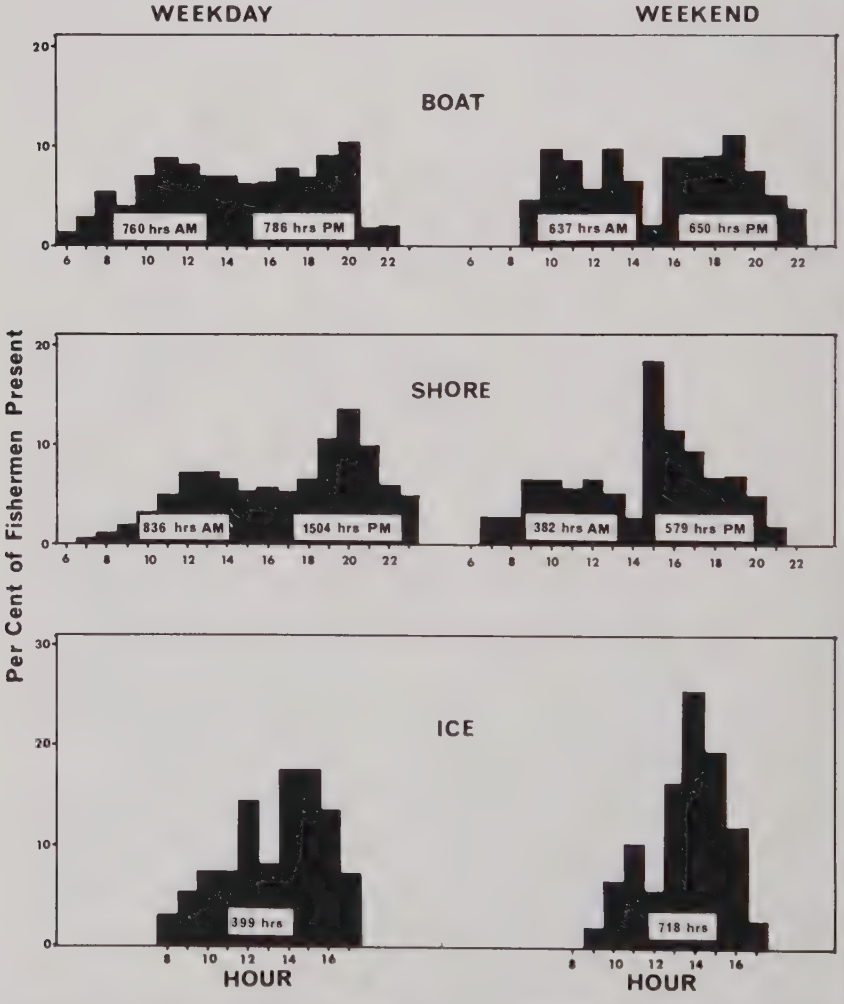

Figure 2. Daily distribution of anglers, given as percentage of fishermen present on the hour, for the 1967-68 fishing season. Estimated number of hours fished are shown on the histogram.

seasons, respectively. Between the falls of 1966 and 1967, the pickerel population declined approximately 50 per cent, and this was a factor in the low catch during the winter of 1966-67 (Green, 1970). In 1967-68 black crappie was the third most abundant species in the ice fishery, but in other years very few were caught. An abundant 1965 year class of crappies reached a size large enough to interest anglers during the summer and fall of 1967, while prior to that the population of catchable crappies had been low (Green, 1970).

MANAGEMENT IMPLICATIONS

In all three years of the census a greater number of anglers at Dryden Lake fished from shore than from boats, although only a limited area of shoreline was accessible. Heavy aquatic weed growth during the summer and relatively low game fish catches did not deter shore fishermen, which suggests a high demand for this type of fishing. Development of fishing docks and piers would probably contribute to more intensive exploitation of panfish. Anglers fishing from shore caught mostly panfish. Boaters harvested a higher proportion of bass and pickerel than did shore fishermen. This poses the interesting possibility of achieving better use of panfish, and perhaps better population balance, by selective development of different types of fishermen-access facilities.

Most creel-census investigations have measured only the number of fish removed, but in this study both fish removed and fish released were recorded. Slightly less than half the fish caught were released in the 1966-67 and 1967-68 seasons (Table 4). From interviews, it was apparent that "fishing for fun" contributed significantly to the high proportion of fish caught and released. Considerable fishing for bass occurred before the season opening, and substantial numbers of bass, pickerel and panfish of legal or acceptable size were released during the open season. This suggests that estimates of fish caught and released, in addition to those harvested, may be required to evaluate the quality of a recreational fishery or the success of a management program. Also, it may be important to consider the mortality of released fish when changing legal size limits or in any evaluation of fishing mortality.

LITERATURE CITED

Cochran, W. G. 1963. Sampling Techniques, 2nd ed. John Wiley and Sons, New York, N.Y.

Green, D. M. 1970. Population, survival rate and growth of sport fish in Dryden Lake. New York Federal Aid Project F-17-R (progress report for Job III-a), N.Y.S. Dept. Environ. Cons. (Mimeo.)

Snedecor, G. W. 1956. Statistical Methods, 5th ed. Iowa State Coll. Press, Ames, Iowa.

DISTRIBUTION OF WALLEYE AND YELLOW PERCH FRY IN A BAY OF ONEIDA LAKE[1]

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ABSTRACT

Densities of walleye and yellow perch fry were usually greater inshore than offshore in samples taken during early June. Walleye fry concentrated at a variable depth, whereas yellow perch fry were uniformly distributed to a depth of 3.7 meters except during calm weather. Although vertical and horizontal distributions of the two species did not coincide, catches were correlated within localized areas. Correlations between the abundance of yellow perch fry and their occurrence in walleye fry stomachs indicated that the association between the two species may have been caused by a predator-prey relationship. The over-all difference in distribution indicated that perch abundance was not the major influence on the distribution of walleye fry.

Studies of distribution of larval walleyes (*Stizostedion v. vitreum*) in Oneida Lake (New York) indicate that newly-hatched larvae are transported by wind-generated currents and are concentrated in shallow bays on the southern shore (Houde and Forney, 1970). Larval yellow perch (*Perca flavescens*), in contrast, are mode widely distributed throughout the lake, occupying the upper 6 meters of the water column (Noble, 1968). The distribution of larvae of the two species in Billington Bay of Oneida Lake was studied by Houde (1969) in relation to zooplankton abundance and water currents. He found that the two species differed both in horizontal and vertical distribution, but a partial correlation between catches of the two species indicated an association between yellow perch and walleye larvae. The present data pertain to the distribution of slightly larger young of the walleye (> 10 millimeters) and yellow perch (> 8 millimeters) in Billington Bay and were obtained in unrelated sampling programs from 1966 to 1968 (Noble, 1970, 1972). They are presented as an extension of the data by Houde (1969) on distribution of larvae of the two species.

MATERIALS AND METHODS

Billington Bay (Figure 1) is a 2-kilometer-long, semiprotected bay on the southern shore of Oneida Lake. For purposes of this study, the 5.5-meter (18-foot) contour was considered the lakeside boundary of the bay.

Fry samples were collected twice weekly from late May to mid-June. Tows with four Miller high-speed samplers, equipped with #00(760μ) mesh nylon monofilament nets, were made parallel to the depth contours at a speed of 13 kilometers (8 miles) per hour on each sampling

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-17-R. Sincere appreciation is expressed to J. L. Forney and E. D. Houde for their critical review and valuable suggestions on the manuscript.

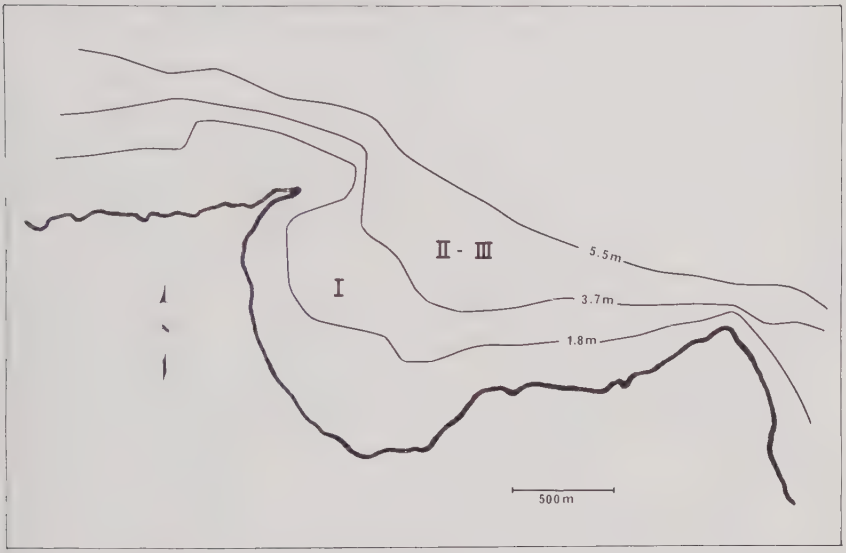

Figure 1. Map of Billington Bay showing sampling strata.

date. Samplers were spaced at equal intervals to the desired depth, and sampling depths were determined from the length and angle of the towing cable. A calibrated Clarke-Bumpus flowmeter was used on all tows to determine the volume strained.

In 1966, the bay was arbitrarily divided into three strata (Figure 1): (I) the inshore area between the 1.8-meter (6-foot) and 3.7-meter (12-foot) contours, sampled to a dapth of 1.8 meters; (II) the offshore area between the 3.7-meter and 5.5-meter (18-foot) contours, sampled to a depth of 1.8 meters; and (III) the water below Stratum II, sampled from depths of 1.8 to 3.7 meters. Two 0.8-kilometer (0.5-mile) tows were made in each stratum on each sampling date, with samplers spaced at 0.5-meter (1.5-foot) depth intervals.

In 1967, four tows were made in Stratum I on each sampling date; Strata II and III were combined, and two tows were made. Tows were 1.1 kilometers (0.7 mile) with samplers spaced at 0.5-meter depth intervals in Stratum I and at 0.9-meter (3-foot) depth intervals in Stratum II-III.

In 1968, six to nine tows were made in Stratum I on seven days, but the offshore strata were not sampled. Each haul consisted of a 1.1-kilometer tow with two samplers at 0.5 meter and two at 1.5 meters.

All samples were preserved in formalin and fry were enumerated in the laboratory. Total lengths, measured to the nearest 0.1 millimeter, were recorded from a representative subsample from each

sampler. Logarithmic transformation of all fry catch data was performed before parametric analyses were made.

RESULTS

The data revealed both similarities and differences in the distribution and other relationships of fry of the two species.

Horizontal Distribution

Catches of walleye fry were consistently higher inshore (Stratum I) than offshore (Strata II and III), except on one day when catches were very low (Table 1). For comparable depths (Strata I and II), the

Table 1. Catches of Walleye and Yellow Perch Fry in Three Areas of Billington Bay in 1966 and 1967

Date	Walleye				Yellow perch			
	Mean length (mm)	Catch per cubic meter			Mean length (mm)	Catch per cubic meter		
		Stratum I	Stratum II	Stratum III		Stratum I	Stratum II	Stratum III
1966								
May 30	10.2	1.47	0.18	0.42	7.9	1.88	1.38	1.93
June 3	11.7	2.00	0.53	0.22	9.7	1.37	1.22	0.36
June 7	13.6	0.38	0.02	0.00	11.3	0.30	0.16	0.03
June 11	16.9	0.11	0.04	0.02	12.8	1.22	0.43	0.28
June 15	18.2	0.00	0.04	0.00	14.2	0.58	0.22	0.65
1967								
June 1	10.2	2.13	0.17	0.34	8.9	2.13	0.81	0.35
June 3	11.2	1.61	0.05	0.03	9.3	0.37	0.23	0.00
June 6	12.4	0.80	0.16	0.13	11.7	0.28	0.06	0.09
June 10	15.8	0.32	0.05	0.07	13.6	2.75	7.38	7.01
June 13	18.1	0.02	0.00	0.00	14.5	9.01	2.95	2.65

catch of walleye fry ranged from three to 19 times higher inshore than offshore in 1966, and from five to 32 times higher in 1967.

Differences in inshore and offshore density of yellow perch were less pronounced. Catches inshore were greater than for comparable depths offshore on all except one day, but the inshore catch never exceeded five times that offshore. There was no tendency for the horizontal distribution of either species to shift during the sampling period or for changes in the distribution of the two species to coincide. Houde (1969), in contrast, found that walleye larvae progressively concentrated in shallow water, whereas the distribution of perch larvae varied in response to water currents.

Vertical Distribution

Walleye fry usually concentrated at some depth between 0.5 meter and the bottom, except on June 3 and 6 in 1967 when concen-

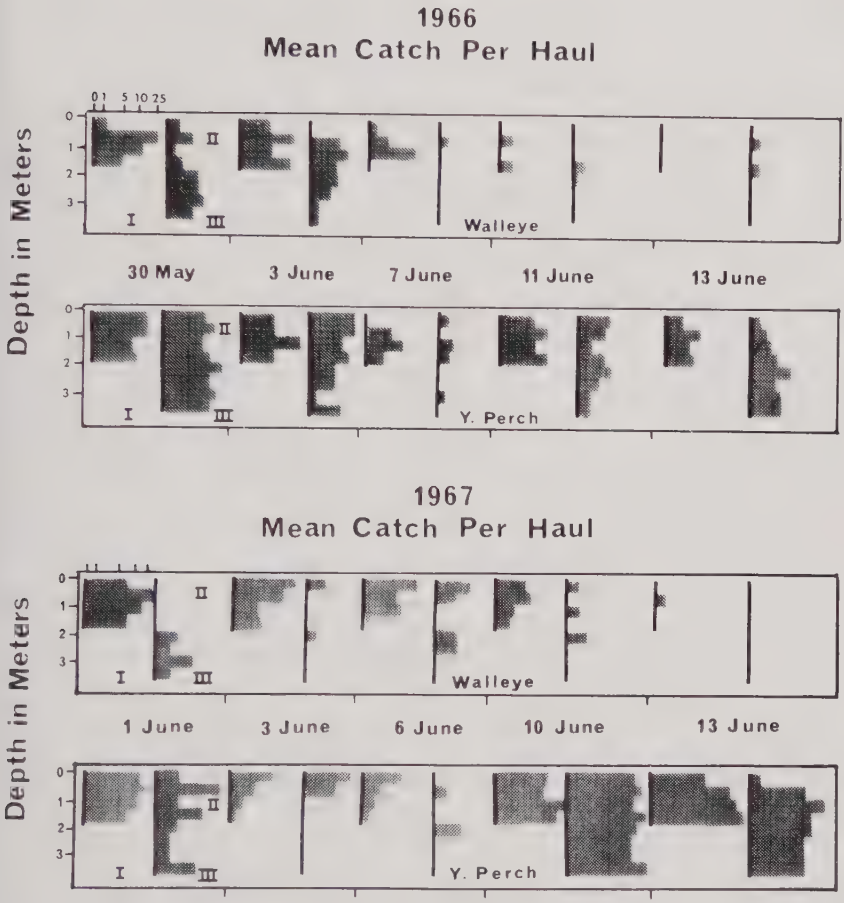

Figure 2. Vertical distribution of walleye and yellow perch fry in Billington Bay in 1966 and 1967. I = inshore stratum (1.8 — 3.7 meters deep); II-III = offshore stratum (3.7 — 5.5 meters deep).

trations were near the surface (Figure 2). The lake surface on those days was calm, whereas on all other sampling dates some turbulence was occurring. Yellow perch fry were more uniformly distributed from the surface to 3.7 meters than walleyes, except for the two calm days when marked concentration at the surface also occurred. No similarity in the vertical distribution of the two species was apparent on other dates. Except for the two calm days, there was no relationship between the depth distribution inshore and that in the upper

2 meters offshore for either species, presumably because of relatively more turbulence in the offshore stratum on most days.

Relation of Walleye Distribution to Yellow Perch

Although vertical and horizontal distribution of walleye and perch fry usually did not coincide, the correlation between catches of the two species was compared on a tow basis to examine possible associations within local areas. To eliminate effects of differences in horizontal distribution of the two species, only catches from Stratum I were used for correlation, and, since only two tows per day were made in this stratum in 1966, only the 1967 data were used. For each day, a simple correlation between logarithms of catch per volume of the two species for each tow in Stratum I was obtained (Table 2). On each of the first three days, high positive correlations were found; however, on the latter two days, walleye catches were so small and variability so great that correlations were low, but nevertheless positive.

To further examine the correlation between the distributions of the two species, data obtained on seven days in 1968 in the same area of Billington Bay were analyzed. These correlations were based on a greater number of tows when fry were more abundant and thus are more reliable than the 1967 estimates. The 1968 correlations, like those

Table 2. Catches of Walleye and Yellow Perch Fry, and Correlations Between Logarithms of Catches, in Stratum I in 1967

Date	Walleye		Yellow perch		Correlation (r)
	Mean length (mm)	Catch per cubic meter	Mean length (mm)	Catch per cubic meter	
June 1	10.2	0.08 4.87 0.62 2.97	8.9	1.58 3.12 1.31 2.53	0.786
June 3	11.2	0.70 1.63 2.45 1.67	9.3	0.15 0.44 0.42 0.48	0.904
June 6	12.4	0.44 0.78 0.57 1.41	11.7	0.06 0.48 0.30 0.31	0.624
June 10	15.8	0.20 0.59 0.46 0.04	13.6	4.38 1.22 4.28 1.14	0.352
June 13	18.1	0.06 0.03 0.00 0.00	14.5	5.89 17.15 3.50 9.48	0.389

TABLE 3. CATCHES OF WALLEYE AND YELLOW PERCH FRY, AND CORRELATIONS BETWEEN LOGARITHMS OF CATCHES, IN BILLINGTON BAY IN 1968

Date	Number tows	Walleye			Yellow perch			Correlation (r)
		Mean length (mm)	Number per cubic meter		Mean length (mm)	Number per cubic meter		
			Mean	Range		Mean	Range	
May 18	6	10.5	2.07	1.12-3.57	7.7	12.75	7.73-20.76	0.433
May 23	6	11.2	1.59	0.95-2.96	9.3	62.69	54.63-70.50	0.518
May 24	6	11.4	2.77	1.52-5.12	9.6	35.45	27.34-41.60	0.822*
May 31	6	13.0	0.71	0.49-0.86	11.8	3.68	2.62- 5.20	-0.027
June 1	9	13.6	0.85	0.29-1.55	12.3	4.59	2.76- 8.60	0.813*
June 4	6	15.4	0.77	0.43-1.18	13.7	4.53	0.95- 6.01	0.647
June 6	9	17.1	0.09	0.00-0.29	14.6	5.16	0.80-11.67	0.724*

* $P < .05$.

for 1967, also were usually positive, but statistically significant on three days (Table 3).

Because of the limited data on which the correlation for each day was based, all correlations for each year were pooled to give a combined estimate of correlation for each year (Snedecor, 1956, p. 178). Correlation coefficients estimated by this method were not significant for 1967 ($r = 0.67$; $P > .05$; df. $= 5$) but highly significant for the more intensive samples of 1968 ($r = 0.62$; $P < .01$; d.f. $= 27$).

These data, like those reported by Houde (1969) for larvae, indicate that associations between walleye and yellow perch fry did occur within a local area, in spite of over-all differences in horizontal and vertical distribution of the two species. Houde suggested that, because walleye larvae are predators upon perch larvae, a predator-prey relationship might have caused the association which began during the larvae stage. To determine whether such a relationship caused the association found in this study, the catch of yellow perch was compared with the percentage of walleyes containing fish. Because no other species of fish was common in the fry samples, all fish found in the stomachs were considered to be yellow perch. Comparisons were made among tows for each sampling date, among sampling dates within each year, and among years. Since adequate sample sizes were needed to estimate the percentages of walleyes consuming fish, only samples from Stratum I were analyzed, and only from the first four sampling days in 1966 and 1967, and from comparable days in 1968.

Correlations among tows within sampling dates were calculated for 1967 and 1968 by weighting the observations according to the number of stomachs examined. The weighted correlation coefficients were consistently positive for 1967 data, ranging from 0.56 to 0.77, but were variable in 1968 (Table 4). In contrast, the daily mean occurrence of fish in stomachs of walleye fry closely paralleled the abundance of yellow perch fry on most days in each year (Figure 3). Furthermore,

TABLE 4. PERCENTAGE OF WALLEYE FRY CONTAINING FISH, ABUNDANCE OF YELLOW PERCH FRY AND WEIGHTED CORRELATIONS FOR STRATUM I FROM 1966 TO 1968

Date	Tow	Number examined	Walleyes containing fish (per cent)	Yellow perch per cubic meter	Correlation (r)
			1966		
May 30	1	72	19.4	1.83	. .
	2	11	9.1	1.93	
June 3	1	43	9.3	1.65	. .
	2	36	2.8	1.08	
June 7	1	7	0.0	0.32	. .
	2	17	0.0	0.28	
June 11	1	3	0.0	1.41	. .
	2	3	0.0	1.03	
			1967		
June 1	1	1	0.0	1.58	
	2	132	6.1	3.12	0.772
	3	5	0.0	1.31	
	4	20	0.0	2.53	
June 3	1	16	6.2	0.15	
	2	52	9.6	0.44	0.560
	3	70	13.3	0.42	
	4	49	10.2	0.48	
June 6*	1	17	0.0	0.27	. .
	2	40	5.0	0.31	
June 10	1	6	16.7	4.38	
	2	17	5.9	1.22	0.566
	3	14	7.1	4.28	
	4	1	0.0	1.14	
			1968		
May 18	1	40	17.5	7.73	
	2	123	22.8	11.85	
	3	55	29.1	11.67	0.038
	4	86	19.8	10.61	
	5	56	17.9	13.86	
	6	77	20.8	20.76	
May 23	1	36	33.3	54.63	
	2	36	61.1	59.63	
	3	102	32.4	65.30	0.426
	4	52	59.6	70.50	
	5	53	24.5	58.17	
	6	48	41.7	67.91	
May 31	1	8	0.0	4.83	
	2	17	6.0	3.02	
	3	23	4.3	3.39	-0.778
	4	30	3.3	5.20	
	5	29	17.2	3.02	
	6	30	16.7	2.62	
June 4	1	18	22.2	0.95	
	2	19	26.3	4.46	
	3	24	12.5	5.98	-0.030
	4	20	30.0	5.95	
	5	41	19.5	3.82	
	6	36	22.2	6.01	

* Two samples accidentally destroyed before stomach analysis.

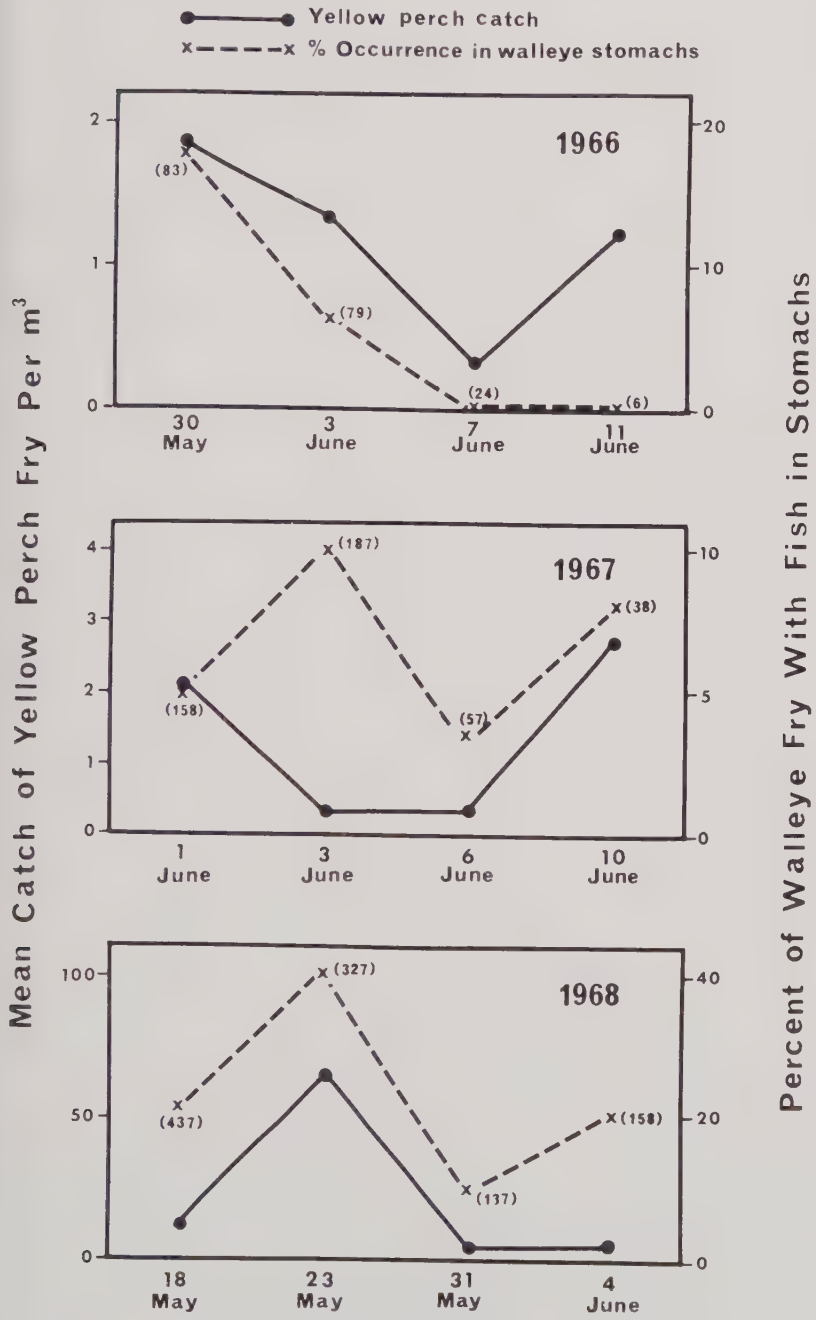

Figure 3. Abundance of yellow perch fry and occurrence of fish in stomachs of walleye fry for Stratum I in Billington Bay from 1966 to 1968. (Figures in parentheses represent number of walleye fry examined)

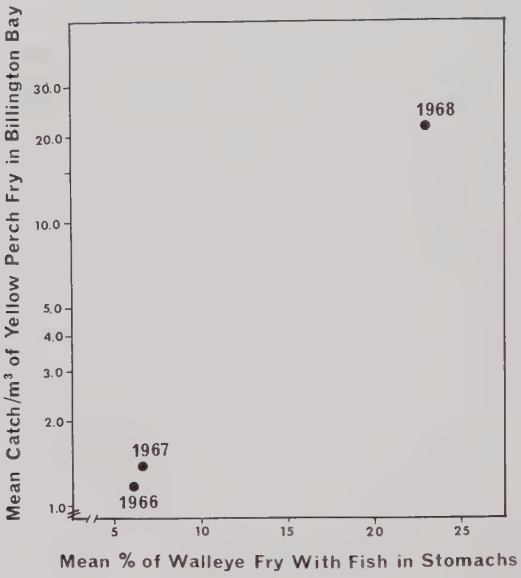

Figure 4. Relation between annual means of yellow perch fry abundance and occurrence of fry in stomachs of walleye fry in Billington Bay from 1966 to 1968.

annual means of the two variables showed a pronounced positive correlation (Figure 4). These correlations, although not explicit on a tow basis, indicate that a high density of yellow perch fry is conducive to higher predation by walleye fry and that an active association of walleye fry with yellow perch concentrations on a local basis might benefit the predaceous walleye fry.

DISCUSSION

This study indicates that the inshore concentration of larval walleyes, as described by Houde (1969), is maintained during the fry stage (> 10 millimeters), but without progressive inshore movements as noted for larvae. In contrast, both Johnson (1969) and Faber (1967) found that walleye fry occurred principally offshore in midwestern lakes. In spite of their ability to swim to other areas of the bay, Oneida Lake walleye fry, like larvae, occupied relatively shallow areas (1.8 to 3.7 meters deep). Large-scale inshore and offshore movements did not occur within the bay, but concentration of fry at certain depths indicated that small vertical movements in response to environmental conditions, particularly surface turbulence, did take place. Johnson (1969) found that catches of walleye fry in some Minnesota lakes were greatest at the surface and decreased with depth, but in clearer waters concentration occurred at greater depths. He made no reference to distribution in relation to surface turbulence.

Yellow perch fry (> 8 millimeters), in contrast, varied in horizontal distribution and were more evenly distributed vertically than walleye fry, except in calm weather when concentration near the surface occurred. Houde (1969) found that perch larvae were more abundant near the surface of Billington Bay, and Noble (1968) found that in the open lake perch fry concentrated in the upper 1.5 meters of the water column, except under conditions of sustained high winds. Such high winds did not occur during the sampling in Billington Bay during this study.

When catches of the two species within one area of the bay were compared, an association was found between them. An unsuccessful attempt was made to show that this distribution resulted from an active association by predaceous walleye fry with their prey, but seasonal and annual variations in abundance of perch fry did correlate with the frequency of occurrence of fry in walleye stomachs. High prey density is therefore conducive to a high intensity of predation, and an active association by walleye fry with perch fry would likely be advantageous to the piscivorous walleye fry. Priegel (1970) found that yellow perch fry in Lake Winnebago (Wisconsin) occurred in the stomachs of walleye fry for a short period during the pelagic stage when perch fry were very abundant; frequency of occurrence reached only 16 per cent compared with 61 per cent on one day in Billington Bay.

The difference in distribution of the two species in spite of their localized association indicates that the major influence on the distribution of walleye fry in Billington Bay is not perch abundance, but some other factor not examined in this study.

LITERATURE CITED

FABER, D. J. 1967. Limnetic larval fish in northern Wisconsin lakes. Jour. Fish. Res. Bd. Canada 24:927-937.

HOUDE, E. D. 1969. Distribution of larval walleye and yellow perch in a bay of Oneida Lake and its relation to water currents and zooplankton. N. Y. Fish and Game Jour. 16:184-205.

HOUDE, E. D., AND J. L. FORNEY. 1970. Effects of water currents on distribution of walleye larvae in Oneida Lake, New York. Jour. Fish. Res. Bd. Canada 27:445-456.

JOHNSON, F. H. 1969. Environmental and species associations of the walleye in Lake Winnibigoshish and connected waters, including observations on food habits and predator-prey relationships. Minn. Cons. Dept., Minn. Fish. Inv. 5:5-36.

NOBLE, R. L. 1968. Mortality rates of pelagic fry of the yellow perch, *Perca flavescens* (Mitchell), in Oneida Lake, New York, and an analysis of the sampling problem. Ph.D. thesis, Cornell Univ. Library.

_____ 1970. Evaluation of the Miller high-speed sampler for sampling yellow perch and walleye fry. Jour. Fish. Res. Bd. Canada 27:1033-1044.

_____ 1972. Mortality rates of walleye fry in a bay of Oneida Lake, New York. Trans. Am. Fish. Soc. 101(4):720-723.

PRIEGEL, G. R. 1970. Reproduction and early life history of the walleye in the Lake Winnebago region. Wis. Dept. Nat. Res., Tech. Bull. 45.

SNEDECOR, G. W. 1956. Statistical Methods, 5th ed. Ioaw State College Press, Ames, Iowa.

GENERAL NOTES

A SHORT-RANGE FORECAST FUNCTION FOR PREDICTING THE RELATIVE ABUNDANCE OF STRIPED BASS IN LONG ISLAND WATERS[1]

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Published scientific literature strongly supports the position that striped bass (*Morone saxatilis*) which occur in Long Island waters originate principally from two sources, namely, Chesapeake Bay (Vladykov and Wallace, 1938, 1952; Chapoton and Sykes, 1961; Mansueti, 1961; Massmann and Pacheco, 1961; Nichols and Miller, 1967) and the Hudson River (Neville, 1940; Raney et al., 1954; Rathjen and Miller, 1957; Alperin, 1966). Moreover, research has further revealed that the Hudson River stocks are relatively endemic, seldom migrating farther east than Fire Island Inlet in the New York Bight or an imaginary line from Bridgeport (Conn.) to Port Jefferson (N.Y.) in Long Island Sound (Raney et al., 1954; Alperin, 1966; Clark, 1968). Most of Long Island's striped bass, especially those which occur seasonally along Suffolk County shorelines, emanate from Chesapeake Bay (Neville et al., 1939; Neville, 1940; Alperin, 1966; Schaefer, 1968). Long Island "striper" fishermen, both commercial and recreational, are therefore extemely dependent upon the recruitment of southern stocks for their fishing success.

Many investigators have observed that increased catches of striped bass are made along the northeastern coast of the United States several years after "dominant" year classes of striped bass are produced in Chesapeake Bay (Merriman, 1937, 1941; Vladykov and Wallace, 1938, 1952; Neville et al., 1939; Neville, 1940; Wallace and Neville, 1942; Tiller, 1950; Alperin, 1966; Schaefer, 1968). Conversely, it has also been observed that decreased catches occur several years after poor year-class production. These observations have led some authors (e.g., Koo, 1970) to suggest that a definable relationship exists between Chesapeake Bay production and subsequent coastal harvest, but such a relationship has been neither formulated nor described in detail. Several questions are prompted: What is the relationship? Is it correlated closely enough for purposes of predicting catch? If so, what is the forecast for striped bass abundance in New York waters over the next several years? Using brood production data for the Maryland waters of Chesapeake Bay and commercial landings data from New York, the author has attempted to provide some answers to these questions.

Based on standardized units of effort, average annual catches of young-of-the-year striped bass have been recorded by Maryland biologists for key spawning and nursery areas of Chesapeake Bay. These data[2] provide an index of year-class abundance for the species since 1954 (Figure 1). Data for commercial landings (in pounds) for New York[3] are also currently available for recent years (Figure 2). The latter statistics may be used as indices of annual striped bass abundance in New York waters, assuming fishing effort to have remained constant over the period. Using the observation that the majority of commercially harvested striped bass in New York are 3-, 4-, 5- and 6-year-old fish (Schaefer, 1968), a regression analysis was made of the relationship between New York landings of striped bass and the average 4-year brood production in Chesapeake Bay 3 to 6 years prior to harvest. This relationship (Figure 3) is described as a straight line ($Y = -519.77 + 151.91X$) with a high correlation coefficient ($r = 0.85$), significant at the .01 probability level ($t_r = 5.01$, $n = 10$). The results suggest that approximately 70 per cent of the variability in annual New York landings of striped bass can be explained by previous annual fluctuations of year-class production in upper Chesapeake Bay.

Inserting the 4-year-average year-class production data for the periods 1966-1969, 1967-1970 and 1968-1971 into the function, estimates (with 95 per cent con-

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[1] Contribution No. 72-3 of the Division of Marine and Coastal Resources.

[2] Provided by courtesy of Joseph Boone of the Maryland Fish and Wildlife Administration.

[3] Data for 1954 through 1970 derived from New York Landings (National Marine Fisheries Service); data for 1971 obtained from Churchill Smith, personal communication.

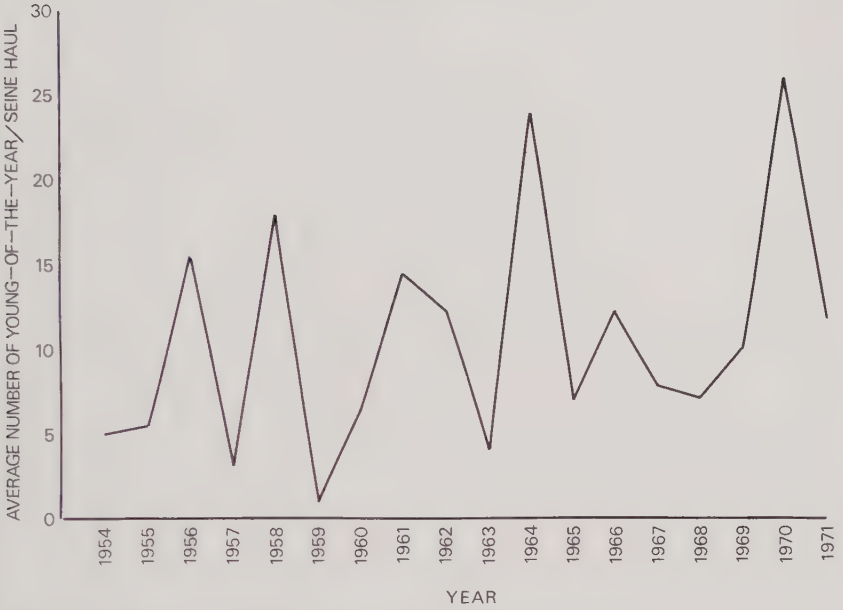

Figure 1. Relative abundance of young-of-the-year striped bass taken from the Maryland waters of Chesapeake Bay, 1954-1971.

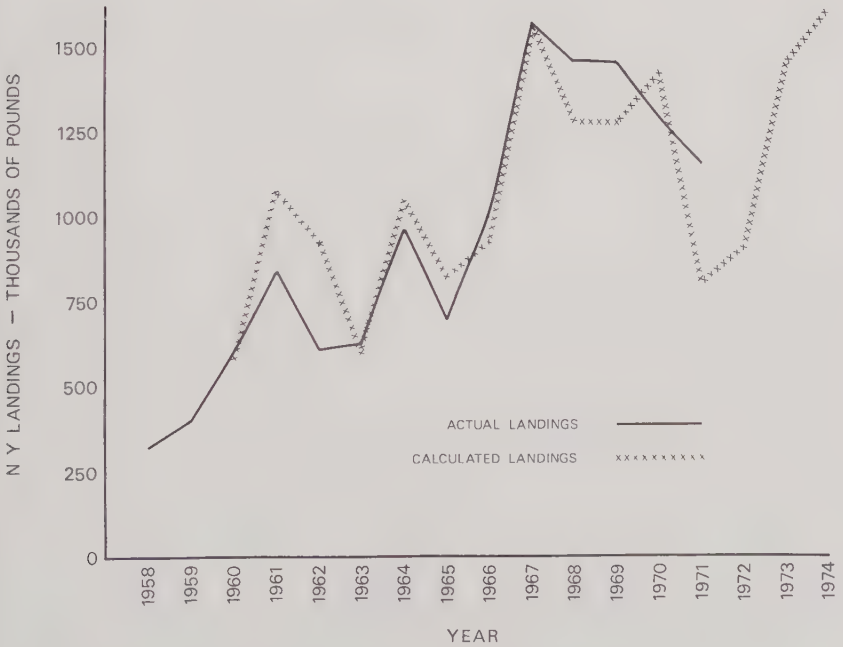

Figure 2. New York commercial landings of striped bass from 1958 to 1971 with calculated landings from 1960 to 1974 superimposed.

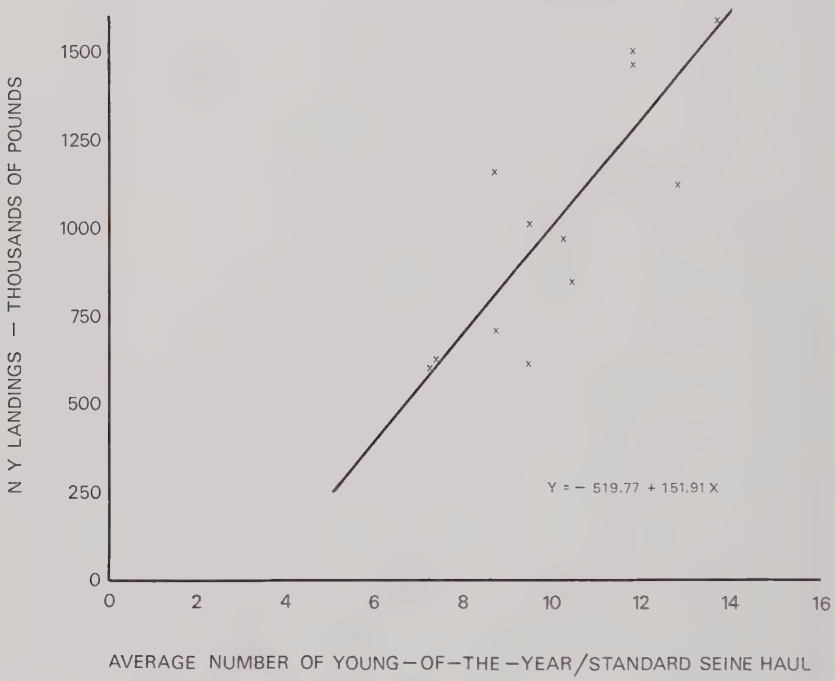

Figure 3. Relationship of New York commercial landings of striped bass to average brood production in the Maryland waters of Chesapeake Bay 3 to 6 years prior to harvest.

fidence limits) of the New York commercial harvest of striped bass may be predicted for 1972, 1973 and 1974. Respectively, the predicted landings (in pounds) are approximately 908,000 (±141,000), 1,455,000 (±231,000) and 1,607,000 (±289,000). These and other back-calculated estimates are superimposed on the actual landings in Figure 2. The accuracy of the predictions, and, therefore, the validity of the forecast function, can only be determined by future commercial harvest data.

LITERATURE CITED

Alperin, Irwin M. 1966. Dispersal, migration and origins of striped bass from Great South Bay, Long Island. N.Y. Fish and Game Jour. 13(1):79-112.

Chapoton, Robert B., and James E. Sykes. 1961. Atlantic coast migrations of large striped bass as evidenced by fisheries and tagging. Trans. Am. Fish. Soc. 90(1):13-20.

Clark, John. 1968. Seasonal movements of striped bass contingents of Long Island Sound and the New York Bight. Trans. Am. Fish. Soc. 97(4):320-343.

Koo, Ted S. Y. 1970. The striped bass fishery in the Atlantic States. Chesapeake Sci. 11(2):73-93.

Mansueti, Romeo J. 1961. Age, growth and movements of the striped bass, *Roccus saxatilis*, taken in size selective fishing gear in Maryland. Chesapeake Sci. 2(1-2):9-36.

Massmann, William H., and Anthony L. Pacheco. 1961. Movements of striped bass in Virginia waters of Chesapeake Bay. Chesapeake Sci. 2(1-2):37-44.

Merriman, Daniel. 1937. Notes on the life history of the striped bass (*Roccus lineatus*). Copeia 1937(1):15-36.

_____ 1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic coast U.S. Fish and Wildl. Serv., Fish Bull. 50(35):1-77.

Neville, William C. 1940. Conservation of striped bass. In: A Study of Certain Marine Fishery Problems of Suffolk County, Long Island, New York. A report of a survey by U.S. Bur. Fish in cooperation with the Suffolk County Board of Supervisors.

Neville, William C., Charles L. Dickinson and James R. Westman. 1939. Striped bass (*Roccus saxatilis*). In: A Biological Survey of the Salt Waters of Long Island, Part I. N.Y.S. Cons. Dept.:107-113.

Nichols, Paul R., and Robert V. Miller. 1967. Seasonal movements of striped bass, *Roccus saxatilis* (Walbaum), tagged and released in the Potomac River, Maryland, 1959-61. Chesapeake Sci. 8(2):102-124.

Raney, Edward C., William S. Woolcott and Albert G. Mehring. 1954. Migratory pattern and racial structure of Atlantic coast striped bass. Trans. 19th N. Am. Wildl. Conf.:376-396.

Rathjen, Warren F., and Lewis C. Miller. 1957. Aspects of the early life history of the striped bass (*Roccus saxatilis*) in the Hudson River, N.Y. Fish and Game Jour. 4(1):43-60.

Schaefer, Richard H. 1968. Size, age composition and migration of striped bass from the surf waters of Long Island. N.Y. Fish and Game Jour. 15(1):1-51.

Tiller, Rchard E. 1950. A five-year study of the striped bass fishery of Maryland, based on analyses of the scales. Chesapeake Biol. Lab., Publ. 85.

Vladykov, Vadim D., and David H. Wallace. 1938. Is the striped bass (*Roccus lineatus*) of Chesapeake Bay a migratory fish? Trans. Am. Fish. Soc. 67:67-86.

_____ 1952. Studies of the striped bass, *Roccus saxatilis* (Walbaum), with special reference to the Chesapeake Bay region during 1936-38. Bull. Bing. Ocean. Coll. 14(1):132-177.

Wallace, David H., and William C. Neville. 1942. The problem of conservation of striped bass on the Atlantic coast. (unpub. ms.)

FIRST RECORD OF A SNOOK FROM NEW YORK WATERS[1]

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The capture of a snook (*Centropomus* sp.) from New York waters was recently reported by Vetter (1971). Subsequent contact with this author revealed that the fish, approximately 11 inches (280 millimeters) in total length, was taken on hook and line from Barnum's Channel near Island Park, N.Y. in early October of 1969. Although the specimen was photographed (Figure 1) immediately after capture, it unfortunately was not retained for closer biological examination. In spite of the absence of corroborating data, however, there seems no reason to doubt the authenticity of the report or the generic identification of the specimen. Moreover, the morphological characteristics of the photographed specimen seem to conform closely to the description given by Rivas (1962) for the common snook (*Centropomus undecimalis*).

This is apparently the first record of a snook from New York waters, and the northernmost for the genus along the Atlantic coast. Faunal literature for southern New England, New York and New Jersey reviewed earlier by Schaefer and Doheny (1970) revealed no previous occurrence for those areas. Indeed, the range for *C. undecimalis,* the most widely distributed member of the genus along the Atlantic

First recorded snook (*Centropomus* sp.) from New York waters. (Photograph courtesy of Donald Vetter and the Long Island Fisherman)

coast, is given generally as estuarine waters from Brazil to northern Florida (Marshall, 1958). In recent years, however, its range has been gradually extended northward as evidenced by the capture of juveniles in Georgia (Linton and Rickards, 1965), South Carolina (Lunz, 1953) and North Carolina (Martin and Shipp, 1971).

[1] Contribution No. 72-4 of the Division of Marine and Coastal Resources.

Barnum's Channel is a tidal, salt-marsh creek which drains into Middle Bay, an estuary near Jones Inlet on the southern shore of Long Island. The specimen was captured from between the piles of an abandoned dock about 250 yards east of the heated-water discharge from a nearby electric-generating facility. Doheny [2] recorded a water temperature of 25.3° C. and salinity of 29.4 ppt at that location on October 6, 1969. These observations are notable in view of the remarks of Marshall (1958) with regard to the habitat of snook in Florida, i.e., "The principal habitat of *C. undecimalis* in Florida has one conspicuous and almost constant feature: mangrove growth on adjacent strand and estuarine swamps." He further indicated that, although *C. undecimalis* can withstand wide ranges of salinity, low water temperature is apparently a major factor limiting its geographical distribution. He suggested that the species will not survive in locations where mean monthly temperatures fall much below 15° C. Although ambient water temperatures in many of Long Island's south-shore bays approach 0° C. during January and February, average temperatures in the vicinity of the power plant during those months have been only slightly lower than the minimum safe level reported for snook. Doheny [2] recorded an average water temperature of 12.5° C. near the outfall site during January and February of 1969 and 1970. Therefore, although the specimen was taken well beyond the normal range of the species, it would appear that environmental conditions in Barnum's Channel approximated the marginal survival requirements of the species.

Since sub-adult and adult snook are not known to travel great distances (Volpe, 1959), it is unlikely that the Barnum's Channel specimen undertook an extensive voluntary migration to New York from more southern waters. Most probably its occurrence was accidental, having been involuntarily transported northward by coastal currents as a larva or juvenile. Subsequent development into sub-adult form could have then occurred in inshore waters. If this conclusion is correct, the size of the specimen at capture further suggests that the fish may have been a resident of New York waters for a year or longer. Volpe (1959) reported that *C. undecimalis* attains a mean calculated fork length of 163 millimeters by the end of the first winter of life and 342 millimeters by the end of the second winter.

LITERATURE CITED

LINTON, THOMAS L., AND WILLIAM L. RICKARDS. 1965. Young common snook on coast of Georgia. Quart. Jour. Florida Acad. Sci. 28(2): 185-189.

LUNZ, G. ROBERT. 1953. First record of the marine fish *Centropomus undecimalis* in South Carolina. Copeia 1953 (4):240.

MARSHALL, ARTHUR R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, *Centropomus undecimalis* (Bloch). Florida St. Bd. Cons., Tech. Series No. 22.

MARTIN, JAMES R., AND ROBERT L. SHIPP. 1971. Occurrence of juvenile snook, *Centropomus undecimalis*, in North Carolina waters. Trans. Am. Fish. Soc. 100(1):131-132.

RIVAS, LUIS RENE. 1962. The Florida fishes of the genus *Centropomus*, commonly known as snook. Quart. Jour. Florida Acad. Sci. 25(1):53-64.

SCHAEFER, RICHARD H., AND THOMAS DOHENY. 1970. A first record of the squirrelfish from New York waters. N.Y. Fish and Game Jour. 17(1):60-61.

VETTER, DONALD. 1971. Tropicals on Long Island. The Long Island Fisherman 6(4):14.

VOLPE, ALFRED V. 1959. Aspects of the biology of the common snook, *Centropomus undecimalis* (Bloch) of southwest Florida. Florida St. Bd. Cons., Tech. Series No. 31.

[2] Thomas Doheny, personal communication.

ANOTHER CASE OF DERMATOPHILOSIS IN WHITE-TAILED DEER

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A 2-week-old female white-tailed deer fawn was picked up in late June 1971 in Crawford Township in Orange County (N.Y.) and transported to the Biothermal Laboratory at Cornell University where it was penned with other fawns being used for research. Upon arrival, it was noted that the fawn had scabs on its head as if it had run into wire. After a week, the fawn had become emaciated, and large areas of encrustations and alopecia were present on the head and forelegs. Small scaley lesions and lumps were scattered over the entire surface of the skin. The fawn was destroyed and submitted to the Pathology Department of the Veterinary Medical School at Cornell. Of the 24 other fawns in the group, 22 showed similar signs, and a second fawn with skin lesions was submitted to the Wildlife Pathology Laboratory at Delmar. A diagnosis of dermatophilosis was made in each of the specimens autopsied. The other infected fawns at the Biothermal Laboratory showed clinical improvement without specific treatment and seemed to undergo spontaneous remission.

This is the third record of this fungus disease among wild white-tailed deer in the State, the two previous instances having been reported by Stone (1972). Of interest is the fact that the fawn came from the same township as the first record which was also the first case of dermatophilosis reported among wildlife in North America (Dean et al., 1961).

LITERATURE CITED

DEAN, D. J., M. A. GORDON, C. W. SEVERINGHAUS, E. T. KROLL AND J. R. REILLY. 1961. Streptothricosis: a new zoonotic disease. N.Y.S. Jour. Med. 61 (8): 1283–1287.

STONE, WARD B. 1972. Dermatophilosis (cutaneous streptothricosis) in a white-tailed deer fawn. N.Y. Fish and Game Jour. 19 (1):92–95.

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